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ABSTRACT

This report is one in a series written on the Resource Requirements Prediction Model (RRPM-1) developed by the National Center for Higher Education Management Systems (NCHEMS). This particular document contains a brief evaluation of the RRPM implementation as well as an historical record of all important events related to the pilot studies of RRPM-1.2. It is presented largely in chronological order as follows: the decision on the approach to the model; the organization of pilot studies; the pilot implementation; and finally the preparation for dissemination of information on RRPM-1.3. The discussion of the pilot implementation is concerned with an overall summary analysis and not the details of the experiences at each of the pilot institutions. (Author/HS)

A RESOURCE REQUIREMENTS PREDICTION MODEL (RRPM-1): REPORT ON THE PILOT STUDIES

Technical Report 21

National Center for Higher Education Management Systems at WICHE

National Center for Higher Education Management Systems at WICHE

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The Western Interstate Commission for Higher Education (WICHE) is a public agency through which the 13 western states work together

. . . to increase educational opportunities for westerners.

. . . to expand the supply of specialized manpower in the West.

. . . to help universities and colleges improve both their programs and their management.

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The Program of the National Center for Higher Education Management Systems at WICHE was proposed by state coordinating agencies and colleges and universities in the West to be under the aegis of the Western Interstate Commission for Higher Education. The National Center for Higher Education Management Systems at WICHE proposes in summary:

To design, develop, and encourage the implementation of management information systems and data bases including common data elements in institutions and agencies of higher education that will:

- provide improved information to higher education administration at all levels.
- facilitate exchange of comparable data among institutions.
- facilitate reporting of comparable information at the state and national levels.

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NATIONAL CENTER FOR HIGHER EDUCATION MANAGEMENT

SYSTEMS AT WICHE

A RESOURCE REQUIREMENTS PREDICTION MODEL (RRPM-1): --REPORT ON THE PILOT STUDIES

NCHEMS Technical Report 21

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National Center for Higher Education Management

Systems at WICHE

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80302

October 1971

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PREFACE

RRPM-1 Documentation

This publication is part of the documentation for the initial NCHEMS Resource Requirements Prediction Model, RRPM-1. The total documentation package consists of a number of publications, a set of computer programs, and a set of visuals to support training. These materials are available individually or in sets. Three sets of documentation have been developed for various purposes.

A. One set of documents is addressed to administrators and/or managers of higher education institutions. It consists of three documents that describe the structure of the model and its use in an institution of higher education:

NCHEMS Technical Report 19, A Resource Requirements Prediction Model (RRPM-1): An Introduction to the Model

NCHEMS Technical Report 20, A Resource Requirements Prediction Model (RRPM-1): Guide for the Project Manager

NCHEMS Technical Report 21, A Resource Requirements Prediction Model (RRPM-1): Report on the Pilot Studies

The Introduction is addressed to higher education administrators, specifically the top administrator who must make a decision whether or not to implement RRPM. It traces briefly the development of RRPM, its design objectives, testing and implementation at pilot institutions, and the resources required for implementation. It also lists some evaluations by the pilot institutions. The Introduction is based in part on the initial description of the model published in January 1971, The Resource Requirements Prediction Model 1 (RRPM-1): An Overview. The material in this document is now contained in the Introduction and in the Guide. The Guide provides information on the structure of the model and the data required by the model to simulate the institution. In addition, the Guide discusses the process of implementation with special attention to modifying the model, testing it, and training personnel in understanding and using the model. Also included in the Guide is an extensive annotated bibliography of literature related to planning in higher education.

B. The second set of documentation is technical information of interest to the systems analyst and the programmer. This documentation set consists of:

NCHEMS Technical Report 22, A Resource Requirements Prediction Model (RRPM-1): Programmer's Manual

NCHEMS Technical Report 23, A Resource Requirements Prediction Model (RRPM-1): Input Specifications

RRPM-1 Input-Output Package

Computer Programs for RRPM System

The Programmer's Manual discusses the details of the RRPM-1 computer programs. It also contains an algebraic representation of RRPM-1 that will be useful in understanding the analytical details of the model. The inputs required for RRPM are described in the Input Specifications. Included are blank input forms for manual data input. Samples of input forms completed for a hypothetical institution and the output reports generated from the sample input data are contained in the Input-Output package. This will facilitate the testing of the programs using the test data set provided on tape.

C. The third set in the documentation package for RRPM-1 contains materials to aid in training on the model. At the present time this package contains:

Resource Requirements Prediction Model (RRPM-1) Technical Workshop Notes

RRPM-1 Visual Aids

The Notes are hard copy reproductions of the visual aids used at the RRPM-1 Technical Workshop conducted by NCHEMS. The RRPM-1 Visual Aids are duplicates of the visuals used in the RRPM-1 Technical Workshop. These materials are made available to encourage institutions to undertake training of their personnel in the use of the model. Additional materials may be added at a later date.

The RRPM system was developed under a USOE Contract No. OEC-0-8-980708-4533(010). The development cost was supplemented in part by the pilot institutions that gave much of their time and resources to testing and implementing the model. The results of this cooperative effort are available to all interested parties at a nominal cost to cover reproduction and distribution. Further details regarding the RRPM project can be obtained by writing to:

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The following table attempts to aid the reader by identifying the relevant areas of the documentation package. The table is based on different levels of interest in the materials relative to the reader's role in implementating and using the RRPM-1 system. The coding in the table refers to the chapter or section in the Technical Reports; e.g. TR 19-5 refers to NCHEMS Technical Report 19, A Resource Requirements Prediction (RRPM-1): An Introduction to the Model, Section 5.

	ADMINISTRATOR/ EXECUTIVE USER	PROJECT MANAGER	ANALYST/ PROGRAMMER
IMPLEMENTATION	TR19-7	TR19-7 TR20-2,8	TR22-5
MODEL USES	TR19-5	TR20-7	TR22-3
PILOT TEST	TR19-4,6 TR21	TR19-4 TR21	TR21
STRUCTURE	TR19-5 TR20-4	TR20-4 TR22-2	TR20-4 TR22-2
OUTPUTS	TR19-A,B	TR19-A,B TR20-7 TR22-4	TR22-4
INPUTS	--------	TR20-5 TR23	TR22-1 TR23
HARDWARE	--------	TR20-3 TR21-1 TR22-2,4	TR22-2,4,5

ACKNOWLEDGMENTS

The editors wish to acknowledge the RRPM-1 Task Force Members and their associates for their contributions. Special thanks are also due Dr. Warren Gulko who initiated this document and helped throughout its preparation.

I

SUMMARY ANALYSIS OF THE RRPM-1 PILOT IMPLEMENTATION

K. M. Hussain, J. S. Martin

1. Introduction

This section contains a brief evaluation of the RRPM implementation as well as a historical record of all important events related to the pilot studies (testing and implementation) of RRPM-1.2. It will be presented largely in chronological order as follows: the decision on the approach to the model; the organization of pilot studies; the pilot implementation; and finally the preparation for dissemination of information on RRPM-1.3.

The discussion of the pilot implementation in this section is concerned with an overall summary analysis and not the details of the experiences at each of the pilot institutions. The latter has been recorded by each institution and is available in the library of the National Center for Higher Education Management Systems. Summaries of each pilot institution's report appear as subsequent chapters within this document.

2. Decision on the Approach

In June, 1968, the U. S. Office of Education funded a proposal by WICHE (Western Interstate Commission for Higher Education) for work on a Management Information System for Higher Education. One of the projects in this proposal was on the development of techniques of long range planning and resource allocation. To initiate this project, an Advisory Design Group, consisting of experts drawn from the states then participating in the WICHE-PMS project was appointed. Twelve of the thirteen WICHE states (California, Oregon, Washington, Idaho, Nevada, Utah, Montana, Wyoming, Colorado, New Mexico, Hawaii, and Alaska) were represented along with Illinois and New York. The membership of the Advisory Design Group is listed in Appendix 1.

The Advisory Design Group, along with staff of WICHE-PMS (WICHE Planning and Management Systems) examined many of the formal approaches to resource allocation already taken in higher education. These included the work at Michigan by H. E. Koenig; CAP:SC (Computer Assisted Planning for Small Colleges) developed by Peat, Marwick, and Michell and Co.; the Cost Simulation Model developed at Berkeley by G. B. Weathersby; and CAMPUS, developed by R. W. Judy and J. B. Levine in Toronto.[1]

The conceptual approach selected by WICHE-PMS was the CSM (Cost Simulation Model) used at Berkeley.[2] It satisfied the design criteria[3] adopted by the Advisory Design Group: conceptually simple enough for easy comprehension by administrators in higher education as well as data and equipment requirements modest enough to be within the capability of many of the institutions participating in the WICHE-PMS project. Furthermore, it was an approach that was used successfully by at least one large institution in the U.S. (University of California at Berkeley).

In selecting the CSM model, it was recognized that the model had to be generalized for "typical" institutions of higher education in the United States and made consistent with the Program Classification Structure, then also being developed by WICHE-PMS. The model was to be concerned primarily with the instructional and support programs, leaving research and public service programs to future versions of the model. Finally, the programs had to be rewritten and documented. It was decided that this job would be contracted to a consulting firm, and the specifications were then sent out to bid. The firm that won the contract for an amount of $18,000 was MATHEMATICA of Princeton, New Jersey, with Roger Sisson as Chief Investigator.

3. Organization of Pilot Studies

MATHEMATICA was to desk check its product to be called the Resource Requirements Prediction Model-1, or RRPM-1, while the field testing and further developments to the model were to be done by a group of pilot institutions. These institutions were to be selected from the thirteen WICHE states in addition to the University of Illinois and the State University of New York System. Institutions interested in participating or merely interested in learning about the RRPM-1 were briefed in two workshops held in March 1970.

Eleven institutions were initially selected by the WICHE Executive Committee. These are listed in Appendix 2. Eight of these institutions (identified in Appendix 2) agreed to perform the pilot studies. All eleven, however, were invited to participate in a Task Force on the RRPM-1. In order to maintain a balance between technical and administrative personnel on the Task Force, each of the institutions was asked to nominate two persons: one technical person and one administrator. From this list, the WICHE-PMS program selected, in April 1970, a group of eleven members, one from each institution. The list of this Task Force is shown in Appendix 3.

One of the first functions of the Task Force was to define the responsibilities of each pilot institution. This was stated in a contract and was signed by each institution. (A copy of the contract appears in Appendix 4.) As a partial reimbursement for the pilot study, each pilot institution was to be given $8,000: $4,000 at the time of the signing of the contract and the remainder on the completion of the contract.

The Task Force spent much of its time in its early meetings in reviewing the structure and data requirements of the model. It soon recognized the need for many modifications. These can be classified into the following three groups:

1. Modifications that were simple and could be done relatively quickly without delaying the implementation schedule of RRPM-1. Also included in this category were modifications that were essential, especially from the viewpoint of data collection. These modifications were to be included in the next version of RRPM-1, referred to as RRPM-1.2 (version 2 of RRPM-1). This was the version that would be implemented by the pilot institutions.

2. Modifications that, if adopted, would delay the implementation schedule but such that they could be done in parallel to the implementation of RRPM-1.2 and incorporated with other modifications arising from the implementation of RRPM-1.2 into RRPM-1.3.

3. Modifications that were conceptual "extensions" of the first model in resource allocation. They would make the model more complex or more inaccessible in terms of resources required for implementation. Such modifications were noted for incorporation in the next RRPM model, then referred to as RRPM-2. A subcommittee of the Task Force[4] was appointed to state design specifications of RRPM-2. These are shown in Appendix 5.

The definition of RRPM-1.2 and the "freezing" of further modifications were difficult but important in that they enabled the pilot institutions to start their implementation without further risk of a change in design and data requirements. This took place in August 1970.

The design of the RRPM-1.2 model (in accordance with the specifications set by the Task Force) and its programming was done by Dr. W. W. Gulko and Mr. J. S. Martin of the PMS staff at WICHE and was available to the pilot institutions in November 1970. The main differences in it as compared to the earlier version of RRPM-1 were the following:

1. The Prediction Module of the programs was split into two (Parts I and II) largely in order to reduce the maximum core requirements.

2. The Report Module was reprogrammed from FORTRAN into COBOL in order to use the COBOL feature of report generation. With rewriting of this program, the flexibility was actually reduced. The capability of reporting on any one or more variables was reduced to a set of fewer but more likely to be used variables. The unnecessary flexibility was traded for a reduction in core requirements, an easier file to work with, and a more readable output.

3. Variable names and subscripts in the program were standardized and the programs were better documented internally.

4. The new version was reprogrammed to incorporate revisions to the Program Classification Structure.

5. The Analytical Module was made a less integral part of the system because no pilot institutions expressed enthusiasm for it.

6. The noninstructional support costs relationships were rewritten to incorporate independent variables that the Task Force considered important.

7. The nonacademic personnel category was disagregated to reflect homogeneous types of personnel. These were:

    a. Professional Management
    b. Technical/Craft
    c. Clerical/Secretarial
    d. Unskilled/Semi-skilled

8. Dimensions were changed for student levels, faculty levels and course levels.

The pilot implementation of RRPM-1.2 involved many technical matters concerning data collection. To get clarification on these problems and to enable an exchange of experiences, technical personnel of each pilot institution met with the WICHE-PMS staff at Boulder in a number of Technical Workshops. In the opinion of the participants, such meetings were very useful.

4. Experiences of Pilot Implementations

This section examines the experiences of pilot institutions in each of the following: project management, data generation, testing, costing, funding and uses of RRPM-1. This discussion is preceded with some general information on the environment of each pilot institution.

4.1 General Information

Some general information on each of the eight pilot institutions is shown in Table 1. As a group they represent both private and public institutions, large and small student enrollments, and a variety in terms of curricula choices and curricula complexities. They also include institutions with special situations relevant for resource allocation such as medical schools (U.C.L.A. and University of Utah), vocational programs (New Mexico Junior College), and military science programs (U.C.L.A.).

The computer equipment used by the pilot institutions varied in size and manufacturer. IBM equipment was predominant, but UNIVAC and CDC equipment were also used. In three cases,[5] the equipment was not on campus; thus the costs of coordination and communication were increased. Also increased was the "response time" for results, but this did not affect performance. The pilot studies showed that a lack of adequate equipment on campus should not dissuade an institution from implementing or using RRPM-1.

TABLE 1
General Information on Pilot Institutions

(as of 1970-71)

	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U.C.L.A.
Funding Public or Private	Public	Public	Public	Private	Public	Public	Public	Public
Year of Founding	1965	1913	1955	1885	1850	1890	1957	1919
Number of Students Enrolled (FTE)	818	5,253	9,741	11,579	18,701	14,532	9,603	28,064
Headcount	1,083	5,672	11,256	11,579	25,517	14,510	11,026	29,093
Curriculum No. of Departments	15	44	34	52	54	86	24	110
Highest Degree Offered	A.A.	M.A./ M.S.	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Ph.D.
Computer Equipment C.P.U.	IBM 360/50	CDC 3300	IBM 360/50	IBM 360/40	UNIVAC 1108	IBM 360/67	IBM 360/67	IBM 360/91
Core	512K	112K (words)	512K	256K	64K (words)	767K	767K	4,000K
Operating System	OS	MASTER	OS	DOS	EXEC 8	OS	OS	OS
System on Campus	NO	NO	NO	YES	YES	YES	YES	YES

4.2 Project Management

The functional location of the project manager and the technique of project control that was used varied greatly among the pilot institutions. This is shown in Table 2.

TABLE 2
Project Management

	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.
Functional Location of Project Manager	Faculty	I.R.	V.P. for Admin.	ADP	O of P	ADP	O of P	O of P
Formal Technique of Project Control Used	PERT GANNT	GANNT	none	none	GANNT	CPM/ PERT	none	none

Legend

IR = Institutional Research

ADP = Administrative Data Processing

O of P = Office of Planning

N.B.

The above are generic names of functional departments. The actual names at an institution vary.

4.3 Data Generation

The amount of data for each set of data elements that had to be generated varied with pilot institutions. These are tabulated in Table 3 in terms of the percentage of data generation required.

TABLE 3

Data Generation in Percentages

	Comm. Coll.	State College		Single Campus University			Part of Multicampus University System		
				Private	Public				
	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.	Comments
ICLM	100C	100B	50B 50C	100B	100B	100B	100B	100B	
Non-ICLM Student Data	100C	100B	100B	100C	100B	100B	100B	100B	
Classes Related Data	20A 20B 60C	100B	25B 75C	100B	80B 20C	100B	80B 20C	100B	
Space Related Data	100C	100B	100C	100A*	75B 25C	60B 40C	100B	90B 10C	*but not used
Personnel Data	40B 60C	100C	10B 90C	100B	40B 60C	100B	80B 20C	100B	
Nonpersonnel Financial Data	100C	100C	100C	100B	90B 10C	100B	100B	80B 20C	
Coefficients for Regression/ Estimation Relationships	100C	25A 75C	100C	100C	80B 20C	100B	100C	100C	

Codes Used

A = Already available in form needed

B = Already available but not in form needed

C = Had to be collected

i.e.. 100C means that 100% of the data had to be collected for RRPM.

Two institutions had to generate almost all their data from the RRPM. Others had most of the basic data in their data base but had to rearrange them to meet the definitional and format requirements of RRPM. In some cases, this required considerable effort. In the experience of the University of Utah:

> "the existence of large amounts of data in machine-readable form proved to be less of an asset than originally anticipated. Matching and merging files designed for different applications uncovered numerous problems of compatability of definitions, code identification, aggregation, etc."[6]

Another data generation problem concerned the cross-over of institutional data to the HEGIS (Higher Education General Information Survey) categories. Portland State found this "difficult, time consuming and frustrating."[7] Other institutions having the same problems included New Mexico Junior College, U.C.L.A., and Washington State. As a consequence, the Task Force agreed that the output of RRPM need not be aggregated by the HEGIS discipline categories but by any level assigned by the institution. This capability is incorporated in the released version RRPM-1.3.

In predicting student enrollment and in determining the cost functions and cost coefficients needed in RRPM, institutions used different approaches. These are shown in Table 4 on the following page.

TABLE 4

Approaches to Data Generation

INSTITUTION	ENROLLMENT PROJECTION	COST FUNCTION DETERMINATION
New Mexico Junior College	1. Judgment	1. Stated Own Estimation Equations
Humboldt State College	1. Judgment 2. Predictions by Office of Institutional Research	1. AM 2. Judgment 3. Chancellor's Office--Policy
Portland State University	1. Own Enrollment Prediction Model	1. Judgment
Stanford University	1. Weighted Average of last 2 years	1. Statistical Package--BIOMED
University of Utah	1. Judgment 2. Own Enrollment Prediction Model	1. Statistical Package--BIOMED 2. Other[1]
SUNY at Stony Brook	1. Own Enrollment Prediction Model (Noncomputerized)	1. Judgment 2. Stated Own Estimation Equations
U. C. L. A.	1. Judgment 2. Own Enrollment Prediction Model	1. Judgment
Washington State University	1. Judgment 2. State Student Flow Model	1. Judgment 2. Statistical Package--GEORGE

[1]Used Long Range Planning data and modified it with judgment on available funding needed.

The approaches selected by institutions as shown in Table 4 were made only after each institution carefully investigated the use of AM, a statistical package developed by MATHEMATICA for use with the RRPM-1. All institutions decided against using AM. Three institutions used statistical packages but not AM. This suggests that approaches other than the AM would be more useful.

Data generation is a sequence of file design and data collection. This sequence was often repeated and recycled largely in response to the changes in the basic RRPM-1 model made by the Task Force. Changes in the estimation equations were also made by the institutions. Recycling was also required because of an incomplete or incorrect data base.

The extent of recycling required by each pilot institution is shown in Table 5. It identifies three institutions that had to recycle their data collection twenty times each suggesting that a future implementer of RRPM-1 should anticipate recycling.

TABLE 5
Number of Recycles for Various States of Implementation

	New Mexico Junior College	Humboldt State College	*Portland State University	Stanford University	University of Utah	Washington State University	*SUNY at Stony Brook	U. C. L. A.
Data File Design	3	1		0	3	1	3	None
Data Collection	20	3		20	20	2	2	None
Cost Estimation Function Specification	5			10	4	4	1	2
Cost Calculation	9			5	7	12	1	6

*Not yet completed

4.4 Training

Strategies of training differed among pilot institutions. These are shown in Table 6.

TABLE 6

Training Strategies Used by Pilot Institutions

	Comm. Coll.	State College		Single Campus University			Part of Multicampus University System		
				Private	Public				
	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.	Comments
Strategies Used									
Lectures	X		X		X				
Seminars	X	X	X			X	X		
Person-to-Person	X	X	X	X	X	X	X	X	
Game	X	X	X						
NCHEMS literature as reading assignments		X							
Levels of Personnel Training									
President	X				X				
Vice-President	X	X	X		X	X		X	At UCLA, this was Vice-Chanc.
Other Administrative Personnel	X	X	X	X	X	X	X	X	In many cases, incl. Anal.Team
Academic Dean(s)		X	X		X		X		
Academic Dept. Heads	X	X			X				
Data Processing	X			X	X	X			
Students		X							

4.5 Time and Effort Analysis

The time and effort spent on each of the main activities by each category of personnel are shown in Table 7.

TABLE 7

Time and Effort Analysis (in Man Months)

	Comm. Coll.	State College		Single Campus University			Part of Multicampus University System		
				Private	Public				
	New Mexico Junior Coll.	Humboldt State Coll.	Portland State Univ.	Stanford University	University of Utah	Washington State Univ.	SUNY at Stony Brook	U. C. L. A.	Average
Effort for Management	7	3	2	2	1	1.5	6	1	2.9
Systems Analyst	14	2.7	9	10	19	14	14	12	11.8
Programmer	41	8.3	8	4	3	12	10	13	12.4
Other*	10	2.25	5	0	0	2	0	6	3.2
Effort for Decision to Use RRPM-1	1		1		1	2.5	2		0.9
Data Collection & Recording	11.5	2.25	15	2.5	11.5	4	10.5	21	9.8
Data Conversion to PM-1 Tape	26	2	8	2	1.5	8	3	2	6.6
Estimation of Cost Coefficients	4	0.5	**	2	1	7	4	0.5	2.7
Special Project (e.g., for WICHE)	21.5	1.5	**	1	3.5	5.75	3	0.5	5.2
Validity Testing	3	1	**	3.5	1	1	4	6	2.8
Management Training	2	4.5	**	1	2	0.75	1.5	0.5	1.7
Analysis & Use of RRPM Output	3	4.5	**	4	1.5	0.5	2	1.5	2.4

*The "other" category includes data preparation personnel, statistical consultants and clerical help.

**Not known at time of table preparation.

4.6 Cost Analysis

The cost to the pilot institutions was of two types: direct cost and indirect cost, where direct costs were out-of-pocket costs and indirect costs were all other costs that have not been accounted for. These costs are shown as totals in Table 8 and in detail separately in Tables 9 and 10 respectively. The total cost components are shown in Table 11 and are expressed as percentages for each institution. The assumptions for calculating direct and indirect costs are stated in the footnotes in Tables 9 and 10. In spite of these assumptions known to each institution, there remain differences in the accounting of these costs because of varying interpretations and accounting practices on each campus.

TABLE 8

Total Costs (in $)

	Comm. College	State College		Single Campus University			Part of Multicampus University System	
				Private	Public			
	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.
Direct Cost	$36,363	$ 9,510	$30,106	$25,000	$37,550	$28,200	$43,000	$12,200
Indirect Cost	$62,187	$16,475	$12,174	$21,500	------	$31,200	$18,000	$27,200
TOTAL COST	$98,550	$25,985	$42,280	$46,500	$37,550	$59,400	$61,000	$39,400

TABLE 9

Direct Costs[1] (in $)

	Comm. College	State College		Single Campus University			Part of Multicampus University System	
				Private	Public			
	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.
Project Management					6,900	2,500	10,000	1,000
Consultant	1,974	1,100	2,401		100			
Prog. & Sys. Anal.	23,888	4,578	11,005		17,000	23,600	20,000	6,200
Secretarial	4,860	470	2,914		3,000	900	3,000	100
Computer[2]			10,062	23,500	9,400		6,000	2,800
EAM		105	1,700	500				300
Travel	4,345	1,945	955	1,000	650	1,200	3,000	1,700
Supplies & Miscellaneous[3]	1,296	1,312	1,069		500		1,000	100
TOTAL	36,363	9,510	30,106	25,000	37,550	28,200	43,000	12,200

[1]Direct Costs are costs incurred for the project that would not otherwise been incurred that year. They are out-of-pocket costs.

[2]Computer costs include cost of CPU computer peripheral equipment (including storage, printer, etc.). It does not include keypunching, verifier, sorter, reproducer, and other processing card equipment costs that should be included in the category of EAM.

[3]The miscellaneous costs include telephoning, duplication services (including xeroxing), servicing costs (such as maintenance on dedicated typewriters but not computer maintenance), and cost for disbursing funds or research overhead in connection with project (if any).

Not included: The time of management involved in making decisions on the project and analyzing results of RRPM, space, and non-computer equipment (e.g., typewriter) used for project.

TABLE 10

Indirect Costs[1] (in $)

	Comm. College	State College		Single Campus University			Part of Multicampus University System	
				Private	Public			
	New Mexico Junior Coll.	Humboldt State Coll.	Portland State Univ.	Stanford University	University of Utah	Washington State Univ.	SUNY at Stony Brook	U. C. L. A.
Project Management	13,233	6,000		4,500			8,000	
Consultant								
Prog. & Sys. Anal.	3,560	5,000		11,000			10,000	17,000
Secretarial/Clerk		800		2,000				2,000
Computer[2]	43,920	3,950				31,200		7,700
EAM	1,474	25						500
Travel		300						
Supplies and Miscellaneous[3]		400		4,000				
TOTAL	62,187	16,475	12,174	21,500		31,200	18,000	27,200

[1] Indirect Costs are sunk costs that would have been incurred even if the institution had not piloted the RRPM. Indirect Costs also include the cost of a graduate student who does not get paid but does contribute to the project. It would also include opportunity costs such as computer time that is a "service" and not "paid for" by the project.

[2] Same as Footnote 2 in Table 8.

[3] Same as Footnote 3 in Table 8.

Not included: Same as given in Table 8.

TABLE 11

Total Costs (in %)

	Comm. College	State College		Single Campus University			Part of Multicampus University System		
				Private	Public				
	New Mexico Junior College	Humboldt State College	Portland State University	Stanford University	University of Utah	Washington State University	SUNY at Stony Brook	U. C. L. A.	Average
Project Management	13.4	23.0	0.0	9.7	18.6	4.2	29.5	2.5	12.6
Consultant	2.0	4.3	8.0		0.3				1.8
Prog. & Sys. Anal.	27.7	36.9	36.6	23.7	45.3	39.2	49.2	59.0	39
Secretarial/Clerk	4.9	4.9	9.7	4.3	8.0	1.5	4.8	5.4	5.4
Computer	44.5	15.1	33.4	53.8	25.0	52.4	9.8	26.7	32.7
EAM	1.5	0.5	5.6					2.0	1.2
Travel	4.4	8.6	3.2		1.7	2.0	4.8	4.0	3.6
Supplies and Miscellaneous	1.3	6.6	3.6	8.6	1.3		1.6	0.3	2.9
TOTAL PERCENTAGE*	100%	100%	100%	100%	100%	100%	100%	100%	

*Details may not add due to rounding.

4.7 Words of Caution

The reader should be cautioned that the cost figures in the previous tables are for pilot testing and implementation. The equivalent figures for future implementation could be much less as a result of institutional pilot experiences. Furthermore, future implementations will not have the many development changes to the basic model nor the costs of exploring new solutions experienced by the pilot institutions. The above tables, however, could be used for projecting costs of future implementations, and this subject is discussed in greater detail in the Introduction to the Model[8] and the Guide for the Project Manager.[9]

4.8 Sources of Funds

The funds for the testing by the pilot institutions came only partly from NCHEMS. The larger part came from the institutions doing the piloting or from other interested parties in the state. The sources of funding are shown in Table 12.

TABLE 12

Sources of Funds (in $)

	Comm. Coll.	State College		Single Campus University: Private	Single Campus University: Public		Part of Multicampus University System	
	New Mexico Junior Coll.	Humboldt State Coll.	Portland State Univ.	Stanford University	University of Utah	Washington State Univ.	SUNY at Stony Brook	U. C. L. A.
NCHEMS at WICHE[1]	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Institution Piloting RRPM	28,000	16,840	16,739	38,500	29,550	51,400	53,000	31,400
Special Subsidy by State for Piloting RRPM	8,000	1,145	17,541					
Other---Specify	54,550[2]							
TOTAL	98,550	25,985	42,280	46,500	37,550	59,400	61,000	39,400

[1]This category does not include the travel expenses for the Task Force incurred by NCHEMS.

[2]Sister institution in state---New Mexico State University's contribution.

4.9 Uses of RRPM-1

RRPM was not used to its potential by any of the pilot institutions largely because it was tested and implemented after the decision-making cycle at the institution had ended. It was, however, used for some limited purposes and this is shown in Table 13.

TABLE 13

Actual Use of RRPM-1

	Comm. Coll.	State College		Single Campus University			Part of Multicampus University System	
				Private	Public			
	New Mexico Junior Coll.	Humboldt State Coll.	Portland State Univ.	Stanford University	University of Utah	Washington State Univ.	SUNY at Stony Brook	U. C. L. A.
Institutional Analysis	X	X	-	-	X	X	-	X
Initiate Planning Process	X	-	-	-	X	-	-	X
1 Year Budget Projection	-	-	-	-	-	-	-	X

Some unexpected by-products were:

1. Provides management training and growth by helping them to understand their institution better (California State College at Humboldt).

2. Determines and organizes in-depth information about organization (New Mexico Junior College and SUNY at Stony Brook).

3. Strong incentive to clean up data base (SUNY at Stony Brook).

4. Cross-validation of institutional model (U.C.L.A.).

The estimates of potential uses of RRPM by the pilot institution are shown in Table 14.

TABLE 14

Anticipated Use of RRPM-1

(Stated in Probabilities)

	Comm. Coll.	State College		Single Campus University			Part of Multicampus University System	
				Private	Public			
	New Mexico Junior Coll.	Humboldt State Coll.	Portland State Univ.	*Stanford University	*University of Utah	Washington State Univ.	SUNY at Stony Brook	U. C. L. A.
Institutional Analysis	Medium	High	High	N.K.	0	Medium	Medium	0
1 Year Budget Projection	High	Low	Medium	N.K.	Low	0	Medium	0
1-5 Year Budget Projection	High	High	High	N.K.	Medium	0	Medium	High
5 Year Forecast	High	Low	Medium	N.K.	High	High	---	Medium
Cutting Budgets	Medium	High	0	N.K.	Medium	0	---	1.0
Increasing Budgets	Medium	Medium	0	N.K.	Medium	0	---	Low
Setting Enrollments	Low	Medium	0	N.K.	Low	0	0	0
Setting Faculty Workload	Medium	Low	High	N.K.	Medium	Medium	0	0
Setting Average Class Size	Medium	Low	High	N.K.	Low	Medium	0	0
Changing Academic Programs	Medium	Medium	High	N.K.	Medium	0	0	0
Sensitivity Analysis	0	Medium	High	N.K.	High	0	Low	0

N.K. = not known at this point

* These universities will use RRPM as shown in table after it is modified.

5. Final Version of RRPM-1

The target date for the completion of all pilot studies was the last meeting of the Task Force in June 1971. At that time, most institutions had either completed their pilot testing or were in the final stages of doing so. Therefore, the date of completion was extended to September 1, 1971. However, institutions were far enough advanced in their testing to discuss the design revisions to the model. They decided that RRPM-1.2 should not be released and that the needed modifications should be incorporated in another version--RRPM-1.3 (to be programmed by the NCHEMS staff) which should then be tested by three pilot institutions[10] and released by late 1971.

The main differences in version 3 over version 2 are the following:

1. An additional routine was added to facilitate simulating answers to "what if" questions. The user can now get answers for "ten" cases i one report.

2. The option of multiple sets of reports was added.

3. Supply and other expenses were disaggregated (for both instructional and noninstructional programs) into the following categories:

   a. Supply Expenses
   b. Travel Expenses
   c. Equipment Expenses

4. The computer programs were slightly modified to correspond to the latest version of the PCS.

5. The computation algorithm for calculating the academic teaching FTE's was changed to allow for differentiation of faculty workload by rank.

The definition of RRPM-1.3 concluded the assignment of the Task Force: that of developing a resource requirements prediction model; but one other related matter that the Task Force considered important was the dissemination of information on RRPM-1.3. The Task Force agreed on a general framework for dissemination and appointed a committee--the Dissemination and Review Committee (DRC) to assist in the preparation and review of materials, documentation, and training aids.

The DRC was appointed by the Technical Council of NCHEMS in July 1971 and was composed of Task Force members from the eight pilot institutions. A subset of this committee[11] was to work with the PMS staff at Boulder in preparing the materials.

6. Dissemination of Information

The DRC subcommittee worked with the NCHEMS staff at WICHE in preparing documentation (as listed elsewhere in this document) for the implementation of RRPM-1.3 and aids for its training. This constituted the completion of the work on the development of RRPM-1.

REFERENCES

1. Detailed references and annotations to discussions of these models appear in _A Resource Requirements Prediction Model (RRPM-1): --Guide for the Project Manager_, NCHEMS Technical Report 20 (Boulder, Colo.: NCHEMS, 1971).

2. Weathersby, G. B. "Development and Application of a University Cost Simulation Model," An unpublished monograph, University of California, Berekely, California, Office of Analytical Studies, June 15, 1967.

3. For a detailed discussion of the design criteria, see the _Resource Requirements Prediction Model (RRPM-1): An Overview_, NCHEMS Technical Report 16 (Boulder, Colo.: NCHEMS, 1971) pp. 8-9.

4. This committee was composed of Mr. P. J. Czajkowski, Mr. M. Roberts, and Dr. D. L. Trautman, working with Dr. W. W. Gulko and Mr. J. S. Martin of the NCHEMS Staff.

5. Institutions will not be identified by name when this information can be found in the tables in this Report.

6. See the detailed report on pilot implementation by the University of Utah, Questionnaire response p. 4. This is available at NCHEMS, Boulder, Colo.

7. See the detailed report on pilot implementation by Portland State, Questionnaire response p. 4. This is available at NCHEMS, Boulder, Colo.

8. _A Resource Requirements Prediction Model (RRPM-1): --An Introduction to the Model_, NCHEMS Technical Report 19, (Boulder, Colo.: NCHEMS, 1971).

9. _A Resource Requirements Prediction Model (RRPM-1): --Guide for the Project Manager_, NCHEMS Technical Report 20, (Boulder, Colo.: NCHEMS, 1971).

10. These pilot institutions were Humboldt State College, New Mexico Junior College at Hobbs and U.C.L.A.

11. This committee consisted of Dr. K. M. Hussain, Dr. D. F. Lawson, Mr. R. J. Low and Mr. M. Roberts.

APPENDIX 1

RESOURCE REQUIREMENTS PREDICTION MODEL

ADVISORY DESIGN GROUP
(April 1969 - March 1970)

Dr. Robert F. Adams
Associate Professor of Economics
University of California at Santa Cruz

Mr. James Farmer
Director, Information Systems
The California State Colleges

Mr. John E. Keller
Director of Analytical Studies
University of California at Berkeley

Dr. Thomas R. Mason
Director of Institutional Research
University of Colorado

Mr. M. Charles McIntyre
Principal Higher Education Specialist
California Coordinating Council for Higher Education

Mr. Gordon D. Osborn
Director of Analytical Studies
State University of New York

Mr. Garland P. Peed
Assistant Superintendent, Business
State Center Junior College District
Fresno, California

Mr. James F. Ryan
Vice-President
Planning and Budgeting
University of Washington

Dr. Robert Wallhaus
Associate Director of Administrative Data Processing
University of Illinois

Dr. George B. Weathersby
Assistant Director
Office of Analytical Studies
University of California at Berkeley

Dr. Martin L. Zeigler
Associate Provost
University of Illinois

CONSULTANTS

Mr. Steve Robinson
Mathematica
Princeton, New Jersey

Mr. Robert L. Sisson
Associate Director
Government Studies and Systems
Philadelphia, Pennsylvania

APPENDIX 2

RRPM-1 PILOT TEST

List of Institutions Selected for Pilot Testing

1. California State Colleges (CDC 3300) Humboldt State College
2. *State Center Junior College District Fresno, California
3. New Mexico Junior College (IBM 360/50: NMSU)
4. Portland State University (IBM 360/50: U of Oregon)
5. Stanford University (IBM 360/40, 256K)
6. State University of New York at Stony Brook (IBM 360/67)
7. University of California at Los Angeles (IBM 360/91)
8. *University of Colorado
9. *University of Illinois
10. University of Utah (UNIVAC 1108)
11. Washington State University (IBM 360/67)

*The asterisk identifies institutions that did not do the pilot testing but participated in the Task Force.

APPENDIX 3

RRPM-1 TASK FORCE
(As of January 1971)

Mr. Peter J. Czajkowski
Manager, Operations Research Division
University of Illinois

Mr. Ted E. Davis
Financial Vice President
University of Utah

Mr. Alan Feddersen
Associate Systems Analyst
California State Colleges

Dr. Henry Fischer
Director, Systems, Services and Development
Washington State University

Mr. Adrian Harris
Director of Planning
University of California, Los Angeles

Dr. K. M. Hussain
Professor of Computer Science
New Mexico State University

Mr. Robert J. Low
Vice President, Administration
Portland State University

Dr. Thomas Mason
Director of Institutional Research
University of Colorado

Mr. Garland P. Peed
Assistant Superintendent, Business
State Center Junior College District
Fresno, California

Mr. Michael Roberts
Director of Administration Computing
Stanford University

Dr. DeForest L. Trautman
Acting Director, Long Range Planning
State University of New York at Stony Brook

Dr. George B. Weathersby
Assistant Director
Office of Analytical Studies
University of California at Berkeley

Principal Staff Members

Dr. Warren W. Gulko
Director, Development and Applications Program

Mr. James S. Martin
Staff Analyst

Mr. Charles R. Thomas
Program Associate for Information Systems

APPENDIX 4

THIS CONTRACT, entered into this day of , 197 between , an Educational Institution havings its principal seat of learning in the State of , hereinafter referred to as the "INSTITUTION", and the WESTERN INTERSTATE COMMISSION FOR HIGHER EDUCATION, a non-profit instrumentality of the thirteen western states commonly and hereinafter referred to as "WICHE":

WITNESSETH:

THAT WHEREAS, the parties wish to provide for completion of the tasks as herein described, associated with the Resource Requirements Prediction Model project, as described by the United States Office of Education Contract Number OEC 0-8-980708-4533(010).

NOW THEREFORE, in consideration of the premises and the promises and agreements of the parties, IT IS AGREED AS FOLLOWS:

THE INSTITUTION AGREES to employ its best efforts:

1. To collect and analyze the Institution's historical data as modified by the judgment of the Institution's administrators in order to validate the models.

2. To structure the input requirements for the Resource Requirement Prediction Model -1 (RRPM-1), so as to be compatible with the WICHE planning and Management Systems Data Element Dictionaries: First Edition, and Program Classification Structure: Preliminary Edition

3. To implement the prototype RRPM-1 utilizing the draft documentation manuals.

4. To validate the documentation and implementation manuals.

5. To conduct a pilot operation of RRPM-1 and to conduct an analysis of the output by the institution's staff.

6. To utilize RRPM-1 in the planning and management of the institution.

7. To provide an analytical team to assist in the operation and evaluation of the model. The analytical team will be selected from among individuals representing the following types of positions:

    a. Senior executive office for academic affairs

    b. Senior executive office for business and finance

    c. Controller

    d. Budget officer

    e. Information systems coordinator or analyst

    f. Qualified technical analyst

    g. Research assistant

    h. Computer programmer

8. To analyze the output of the prototype RRPM-1 model and to compare it with known values under actual operating conditions.

9. To participate in institutional review and workshop conferences designed to review progress and discuss any problems associated with pre-implementation and pilot operations.

10. To provide information regarding problems associated with implementing the prototype RRPM-1. General critera of acceptability for the institutional reports include the following items:

    a. An analysis of any data acquisition problems.

    b. Technical difficulties in operating or implementing the model.

    c. An estimate of the cost of model operation.

    d. The deficiencies and short-comings of the prototype model as it applies to the institution.

    e. A statement of the historical validity test and an analysis of any differences that occurred between actual resource requirements.

    f. A statement from a senior executive evaluating the potential worth of the model for the planning and management of the institution.

11. To take principal responsibility with assistance from the other participating institutions of the following task:

12. To advise   in the accomplishment of the following task:

13. To complete all obligations under the contract by May 30, 1971.

14. To practice non-discrimination in employment (Section 202, Executive Order 12246, September 24, 1965, 30 FR 11269 is made a part of this contract by reference).

15. To certify that only nonsegregated facilities will be used in compliance with Federal Regulations (the statement provided by DHEW concerning certification of nonsegregated facilities is made a part of this contract by reference).

WICHE AGREES:

1. To pay to the institution the sum of Eight Thousand Dollars ($8,000.00) upon completion of the herein designated work in a manner satisfactory to the undersigned WICHE representative, and upon acceptance by WICHE of the documents, materials and articles resulting from that work, and upon payment to WICHE by the Federal Government of the sums provided for in contract number OEC-0-8-980708-4533(010). Progress payments not to exceed a total of Four Thousand Dollars ($4,000.00) may be paid to the institution prior to the completion of all contractual obligations.

THE PARTIES MUTUALLY AGREE:

1. That WICHE shall have the right to use and to grant to other parties the right to use and/or publish any part or parts of any summary, abstract or revision of the publications, materials, and computer programs resulting from this contract shall be in the public domain and shall not be considered the property of the institution or the Western Interstate Commission for Higher Education.

2. The contracting officer (the U. S. Office of Education) reserves the right to use and/or publish and to grant to any other parties the right to use and/or publish any part or parts of any summary, abstract or revision of the publications, reports, materials, and records resulting from this contract.

IN WITNESS WHEREOF, the parties hereto have caused their names and seals to be affixed by their authorized officers as of the day and year first above written.

WESTERN INTERSTATE COMMISSION
FOR HIGHER EDUCATION

By________________________ By________________________

Title_______________________ Title_______________________

RRPM-1 PILOT TEST SPECIFIC INSTITUTIONAL TASKS

HUMBOLDT STATE COLLEGE	The institution will undertake a detailed examination of the RRPM-1 to determine efficient means of reducing the core requirements. This will include a step-by-step discussion of changes to the model to reduce the core requirement, including the implication of such changes or reductions.
NEW MEXICO JUNIOR COLLEGE	The institution will develop a preprocessor for the PM input data. Development of a preprocessor has three purposes: a) to provide for a formated printout of a given set of RRPM-1 input; b) to provide a validity check of a particular input file with a summarized set of diagnostic errors and potential errors; c) to update a given set of RRPM-1 input for the purpose of either correcting data on the file or establishing an experimental file by changing certain numbers in the base data set.
PORTLAND STATE UNIVERSITY	The institution will undertake a study to determine which of the variables within the model are, under most situations, uncontrollable variables in that they are not subject to management control; and which of the variables are, in the general case, controllable in that management may exercise some discretion over their values. Included will be an investigation of systems of equations which may be influenced in part by management decisions. Directly related to this task is the determination of which variables must necessarily be predicted by some statistical technique, e.g., regression, and which variables may be preset or specified by the decision maker.
STANFORD UNIVERSITY	The institution will conduct a test of the program logic to verify that each of the program statements and subroutines do, in fact, produce the results that are intended. Included within this test will be the verification of the associated documentation and modification where necessary in either the programs or the documentation.

The institution will develop input forms to aid in the collection and key punching of data for input to the RRPM-1.

STATE UNIVERSITY OF NEW YORK AT STONY BROOK	The institution will undertake a study to determine the importance of each variable in the model from a cost/effectiveness standpoint in order to identify those variables which may be of little significance to the prediction function of the model, including an evaluation of data collection costs and costs in terms of operating the computer programs. The importance of the variables should be considered at the discipline level, the program level, and the total campus level. Included will be a recommendation of the manner in which institutions should conduct such determination.
UNIVERSITY OF CALIFORNIA AT LOS ANGELES	The institution will develop the necessary computer software and associated documentation to operate the RRPM-1 from a remote terminal. The changes to the RRPM-1 system which are required for on-line, real time terminal operation will be identified including an analysis of the hardware implications and cost associated with such changes.
UNIVERSITY OF UTAH	The institution will develop a set of recommended changes to the report module to include data graphing and formatting of data for management decisions. Data graphing tasks will include producing examples of computer drawn charts together with specifying the hardware and software requirements to produce the charts. The data formatting task will include an extension of the current report module to calculate rations, rank decision variables, and highlight other important data for management decisions making.
WASHINGTON STATE UNIVERSITY	The institution will pursue the development of an analytical program (a procedure) which will determine the sensitivity of any specified dependent variables. The ability to define both the absolute value and the functional relationship will be investigated. The program will assume that the model conforms to the basic RRPM-1 structure without optional relationships.

To the extent that such a program (a procedure) proves practical such will be demonstrated by application of the sensitivity analysis program to the RRPM-1 developed as a part of this same contract.

APPENDIX 5

PROPOSED RECOMMENDATIONS FOR RRPM-2 BY RRPM-2 SUBCOMMITTEE

OF RRPM-1 TASK FORCE

The RRPM-2 Subcommittee has held two meetings which were concerned with outlining the conceptual framework for the development of the second phase of the Resource Requirements Prediction Model Project. In general, it is recommended that the project address the question of short-term budget decisions and the long-term implications of such decisions, that the model design be modular in concept, and that it provide extensive detail for department level decision making which may then be aggregated to a college or division level and ultimately to campus level decisions. The underlying concept of the RRPM-2 System shall be a model which facilitates short-term budgetary decision making and estimates the long-term implications of short-term decisions. The model design will accommodate detail information for budgetary decisions (first two years) and more aggregate data for long-term predictions. Such a model should consist of a number of modules, but we may think of the system as two major sections: a budget subsystem (suggested acronym "PROBE" for program budget estimator) and an estimation subsystem which calculates the long-term implications of the short-term budgetary decisions. The PROBE subsystem should provide the capability to examine alternative budgetary decisions, particularly to distinguish between the fixed budgetary obligations of the institution and those program activities which may be considered available for tradeoff. In addition, consideration should be given to the development of techniques which facilitate or guide the user in the selection of parameter values for the model. Such techniques may be developed as a separate module within the overall system.

Target Audience

Although the potential users of sophisticated simulation models may be quite limited at the present time, it is the opinion of the Subcommittee that the target audience for RRPM-2 will expand significantly within the next two years. This expansion will be the result of improved data capability at the institutions and a heightened interest on the part of management for modern technologies to aid in the planning and budgeting in higher education. As a result, it is the recommendation of the Subcommittee that the RRPM-2 model be designed in such a fashion that it accomodates the needs of both small and large institutions, recognizing that the initial users will tend to be those schools with advanced systems. For the purposes of the initial efforts, the general orientation of the RRPM system should be to institutional decision making as contrasted to state and national decision making.

The model should be oriented to both the college and university use; however, it is recommended that at the present time RRPM-2 exclude the health education area. The complexities of health education management systems are such that simulation of this area requires special attention and unique expertise that are not accommodated within the current project.

Optimization

It is recommended that the RRPM-2 system not be directed toward optimization. However, provision should be made for development of suboptimization modules in areas where appropriate. It is also recommended that Geoffrion's work at UCLA be investigated with regard to its applicability to the RRPM-2 system. Work with regard to the application of optimization techniques within higher education should be considered by the Center's Research Unit and may be incorporated when suitable procedures are available. In this regard, consideration was given to the goal programming model proposed by Bob Wallhaus. While this model is not directed toward optimization of a true institutional objective function it has a potential for application to decision making in higher education in the same context as RRPM and may also be useful for multi-institution planning. At the present time, the Research Unit is investigating the development of this and other modeling techniques.

Experimentation

The ease by which the user can examine the implications of alternative policy decisions is perhaps the most important aspect in the design of RRPM-2. The modular, hierarchial structure may facilitate the experimentation uses of the model. It is recommended that significant attention be given to the problems of designing a model which will facilitate the asking of "what if" questions.

Additional Systems Modules

Consideration has been given to the development of additional modules which may be incorporated within the RRPM-2 system. Included within this category are such things as a Student Flow Module, Faculty Flow Module, and a Revenue Forecasting Module. In general, it is recommended that the design of RRPM-2 be undertaken with consideration being given to the incorporation of other models being developed within the Center's activities. The RRPM-2 should be able to be used in conjunction with other Center products via standard interfaces.

Utilization of Existing Software

The question of new versus revised software is primarily one of economics: is it less expensive in terms of design and implementation costs to develop new software or to revise existing packages? This question must be answered by a detailed technical analysis which would follow further definition of the objectives and design criteria. There is, at the present time, no way of resolving this question until the RRPM-2 design is definitized. At that time, it is recommended that the staff review software that is available for the purposes of incorporating existing work in the RRPM-2. However, the RRPM-2 system should not be constrained by adherence to existing software designs.

II

SUMMARY OF RRPM IMPLEMENTATION

AT HUMBOLDT STATE COLLEGE

D. F. Lawson, J. Busby, A. Feddersen, F. Jewett

I. THE PLAN OF THE PILOT TEST

A. The people Involved

RRPM was implemented and evaluated at Humboldt State College by and through the Office of Institutional Research. Two groups were involved in the implementation and testing process: a project group and a management evaluation group.

Although the contract was with the college, the effort by the project group was, in actuality, a joint effort with the Divison of Analytic Studies, Office of the Chancellor of the California State Colleges. The venture was truly a team effort. All four of the individuals involved participated as equals, each contributing his particular skills and talents. The project group consisted of:

Donald F. Lawson	Director of Institutional Research, HSC
John C. Busby, II	Analyst, Office of Institutional Research, HSC
Frank I. Jewett	Associate Professor, Department of Economics, HSC
Alan P. Feddersen	Analyst, Analytic Studies, Chancellor's Office

The Director of Institutional Research acted as coordinator and let the strategy of implementation and evaluation. The two analysts took charge of the technical and data capturing problems and saw to it that the model became operational. The economist concentrated on the conceptual and quantitative aspects. The three college members worked with the management evaluation group.

B. The Pilot Test Strategy

Briefly, the overall philosophy followed in the managerial aspects of RRPM testing and evaluation was that the various sub-units of an organization should work together as a team in a common endeavor to achieve the goals of the organization and that in such an environment collective wisdom takes precedence over personal convictions. With this in mind an effort was made to interest a wide variety of campus planners and decision makers in evaluating models in general and RRPM in particular, and then to involve them in a thorough and objective presentation of the subject. More than this, the Office of Institutional Research committed itself to represent this collective wisdom both in its program on campus and its reporting to the National Center for Higher Education Management Systems at WICHE.

This strategy began at the moment that the Office of Institutional Research was asked if it would like to become involved in pilot testing RRPM. The relevant organizational sub-units on campus were contacted and presented the facts of the issue: nature of RRPM, nature of the pilot testing process, possible benefits, probable costs in terms of time, resources, etc. Then the question was asked, "Do you think this college should become involved in such an endeavor and, if so, will you commit the necessary time and resources required of your office?" The reaction was unanimous, and Humboldt State College became involved...and committed.

Pilot testing and evaluation of RRPM consisted of essentially three phases.

Phase 1 occupied the first three months of the project (mid-January to mid-April). The primary goals for this phase were to examine the technical aspects of the model; relating these to the structure and processes of Humboldt State, the California State Colleges, and the computer facilities available,[1] meeting the specific data requirements of RRPM; and trying to get the software to perform with college data. Fortunately the existing data base, including the induced course load matrix, satisfied the data requirements quite well. During this time contact with those outside the project group was limited to:

1. Meetings with key administrators to discuss ways in which RRPM might best adapt to and reflect the college.

2. Biweekly meeting of the President's Council.[2]

3. People contributing radom comments.

4. A formal presentation before the California State College Executive Deans and Building Coordinators.

Phase 2 of the effort was preparation for management evaluation of the model. This included (1) validating the technical aspects of the model and bringing it into reasonable tolerances so that it could be used in prediction and simulation, and (2) forming a management evaluation group. The target dates were April 1 for the first full run of RRPM with actual data, April 30 for bringing the model into control (including a certain set of additional revisions/adaptations), April 26 for formulation of the management evaluation group, and May 1 for the start of Phase 3--training and evaluation.

The first run date slipped to April 10. Data transmission problems in the newly installed telecommunications system moved the model control target until almost the fourth week in May and precluded testing and installation of additional revisions and adaptations. This caused alterations in the timing, breadth, and depth of the management evaluation plan. An early April meeting of the Institutional Research Advisory Committee devoted to RRPM was held as planned, as was a one-and-a-half-hour mid-April presentation of models and RRPM before the President's Council, and a several-hour group discussion of planning models and RRPM with an individual who was spending quite a bit of time traveling around the country studying this subject.[3] The technical problems delayed formalization of the management evaluation group until mid-May. A great quantity of materials were sent to all members of the President's Council, Institutional Research Advisory Committee, and selected other individuals.

Phase 3, management and technical evaluation, began on May 14. Members of the Institutional Research Advisory Committee, President's Council, and the College Budget Officer were invited to join the management evaluation group. Nineteen voluntarily stated an intention to participate in the process. Sixteen participated in most or all of the training, decision, and evaluation sessions.

All of the individuals involved in management evaluation had gained a familiarity with the concepts of language concerning models and RRPM prior to this time through the efforts of the Office of Institutional Research. Building upon this background a two-hour session was held to examine inputs, outputs, and logic in greater detail. Due to its size the evaluation group was actually divided into two training groups and, therefore, two training sessions occurred (May 14-25). The entire evaluation group then met five more times to work with the model in testing and evaluation (May 27-June 9). These were called decision sessions--in the sense that policy and planning decisions were being simulated in order to test and evaluate RRPM. During the decision sessions certain errors in the input and technical deficiencies in the model were pointed out by the management group and appropriate action was taken by the project group.

C. The Decision Sessions

The five sets of decisions made by the management group to exercise the model were as follows:

Decision set 1.

Changed average section size by level and type of instruction from actual to a set of figures to reflect a possible policy statement, to reflect more reality in staffing projections (viz., if graduate area A had an average section size of one and a possible forecast increased enrollment in courses in graduate area A by twelve students, the model would produce twelve additional sections and a requirement of three new faculty positions), and to try and reflect a minimum section size concept. This was retained for future decisions.

Decision set 2.

Made two sets of enrollment projections by major and level of student to master plan size. Set one was a proportionate increase, and set two reflected a number of possible planning and policy decisions concerning the ultimate character and objectives of Humboldt State. This also displayed the relative ease in making such a decision set. An administrator could create the input in a half-hour or so--more quickly if he only wanted to make limited changes.

It was particularly interesting to note the disproportionate demand created by a change in student mix (through the distribution mechanism of the ICLM) in the second enrollment projection. This was quickly seen and commented upon by the management group. Visualize that a doubling of, say, Forestry majors would result in almost a proportionate increase in demand for Forestry courses; but that a doubling of Theater Arts majors is accompanied by less than a twenty-five percent increase in demand for Theater Arts courses. This gives added insight into costing and analysis--cost per major information is superior to cost per departmental credit hour for many purposes. The latter has predominated because of availability. The former is becoming available through program budgeting, the ICLM, and the development of models using both of these concepts.

This set of decisions was retained for future decisions.

Decision set 3.

By using a preprocessor, certain instructional costs (data processing, oceanographic research vessel, marine laboratory, forest maintenance, fisheries food supply, wildlife supplies, equipment, travel, and operating expenses) were distributed according to actual department use rather than by student credit hours across all departments (as per software provided by NCHEMS). This showed the ease with which planners can try out differences in instructional technique, etc., and its impact upon costs--most especially relative costs. A percentage of computer costs were distributed in this manner. Even though the Department of Theater Arts, for example, was not charged with any instructional computer expense and costs based upon the department usage, the cost of a Theater Arts major now increased (through the ICLM) by a few cents. Apparently at least one Theater Arts major took instruction in an area where the computer was used. Even through RRPM was designed for long-range prediction, the reader can see that it is, in this case, being tested and adapted in a short-run simulation mode.

This decision set was used in the following decisions.

Decision set 4.

Several space factors were changed: (1) utilization was changed from actual to standards where appropriate; (2) the physical education formula was changed from actual to a rule-of-thumb supplied by the Chancellor's Office; and (3) for fun the change in formula needed to show that one program needed the entire space of the building in which it was housed was displayed. To the delight of some they could now see that more laboratory space was needed in some of their departments to serve even the existing student load--and they provided forceful prodding to plan for additional special use space for the master plan campus (mix yet to be determined). These space changes were kept for the next and last decision set.

Decision set 5.

An attempt was made here to express (1) a nine-unit load, (2) a quality program and, (3) an intensive utilization of resources. A nine-unit load was expressed in one relatively semicontained instructional unit. In two others, instructional load, faculty mix, and average class size (all by level of course and instructional type) were adjusted to reflect one of the two conditions. One gentleman, who had recently joined the Humboldt team from a well known university said, in response to the higher quality program changes, "Now these costs are more in line with what they were from where I came, and what they ought to be here!"

As might be expected, evaluation was taking place through all of the decision sessions. Two three-hour sessions were planned (June 9, 10) to probe deeper and summarize. Only one of these was needed.

II. THE RESULTS OF THE PILOT TEST

A. Adaptation of RRPM

Initial examination of the model disclosed certain model features that might preclude serious consideration as a usable tool by the administration. At the discretion of the project group, and with the advice of the management evaluation group, a number of significant changes were made in the model to permit a more useful and accurate representation of a California State College, in general, and Humboldt State College in particular.

In the interest of making the output of the model most usable for planning purposes at this institution, it was decided not to use the 30 HEGIS discipline categories but to consolidate 44 departments into 33 departments. This would allow the maximum amount of detail information to be retained during the processing.

Another change involved the classification of personnel in a manner which differed from the standard usage of the model. The model was designed to represent four non-academic staff ranks in each of the Program Classification Structure Support Subprograms (professional/management, technical/craft, clerical/secretarial, and unskilled/semi-skilled). In the California State Colleges staff personnel are classified for reporting purposes according to function. A crossover of Humboldt's functional areas to the various program budget subprograms was created and since the administrators at Humboldt prefer to think in terms of functional areas rather than of personnel aggregated by rank within the subprograms, the functional areas were substituted for the staff ranks.

A change was also made in the regression portion of RRPM, particularly in the Instruction Program. In general for the California State Colleges, administrators, administrative clerical, and technical/clerical personnel under Instruction are allocated by formula at the campus level rather than at, say, the department level. RRPM, utilizing history data for the various departments, projects the requirements for these categories of personnel by department. Since history data by department is difficult to obtain, it was decided to use one regression each for determining total positions for administrators, administrative clerical, and technical/clerical personnel. The resulting positions of each category were then prorated to each department according to the number of faculty already estimated for each department. The result is that certain personnel requirements were estimated using a normative approach rather than an approach based on historical data.

To handle supply cost under Instruction it would be necessary to gather history data for each department in order to develop coefficients for a regression for each department. Since supply and equipment costs for the Colleges are allocated to a campus and not to departments, one regression was developed to generate supply cost on an overall basis and then administratively derived coefficients were used to apportion this cost across departments.

A second problem arose in relation to Instruction supply cost. Certain Support Subprograms, which directly service the departments, also contribute to the cost of Instruction via supply cost. Approximately 60 percent of the cost of Computing Support historically was attributable to Instruction. Of this $140,000, 38 percent is incurred by students enrolled in mathematics courses. When this portion is added back into the other Mathematics department costs, the cost per credit hour is increased by approximately five dollars.

The prototype version had no provision for allocating any of the support subprogram costs back to the departments. A preprocessor was developed to permit portions of the Support Subprogram costs which could be identified with a department to be included as a cost of the department. Using this method, a weighted distribution of the costs of up to 25 items could be made. Those costs used in the preprocessor at HSC were data processing, oceanographic vessel, marine laboratory, forest maintenance, fisheries food supply, wildlife supplies, equipment, travel, and operating expenses. It should be emphasized that only those costs selected by the user are included with the supply and salary costs for computation of the total cost and average unit costs of the departments.

Another change made was in the ICLM. A matrix of coefficients is used rather than the values for weekly student credit hours. Used with factors for average student load, by level of student, this change facilitates examination of the effects of changing student demand and the effects of increasing enrollment with no increase in faculty.

The Research and Public Service Primary Programs were omitted from this implementation of the model because these two programs account for such a small percentage of the budget in this State College system. In general, four-year colleges, such as this one, will be primarily oriented toward providing a regular instruction program.

Analysis of ten years of data collected from the Governor's Budget (1960/61 to 1970/71) revealed that staff positions and operating expenses of most of the Support Subprograms were directly related to the number of FTE students and FTE faculty. The equations in the prototype were changed to reflect these relationships.

In an effort to preclude misinterpretation of any of the output information which might leave the Humboldt campus, the evaluation group directed that the report titles be changed to include the words "Management Game."

B. Validation of RRPM

The 1970/71 academic year at Humboldt was selected for numerical validation of RRPM. RRPM was run so that projections for resource requirements proceeded from 1970/71 as a base year, 1970/71 representing the most recent year for which data existed; e.g., average salary costs, an induced course load matrix, etc. The obvious task was to check the predicted model figures against what was actually budgeted for 1970/71. Years 1971/72, 1972/73, etc., in the model output, of course, became the actual forecast years for planning purposes, Using 1970/71 as a base year for forecasting makes sense intuitively since forecasts tend to be made based on the most recent information. If the base year of 1970/71 does not validate well, then forecasts become questionable; if validation looks good, there are no assurances that the forecasts are infallible but rather there does exist some justifiable confidence in them taking into consideration the assumptions underlying the model.

Before discussing the validation results two important topics related to validating RRPM need to be treated. The Instruction portion of RRPM (handled in RP) is undoubtedly the most significant element of RRPM both in terms of the amount of cost that Instruction contributes to the overall budget cost and in terms of the amount of beneficial information avialable to the decision maker. Since the Instruction element of RRPM performs its computations by department, it is appropriate to validate the model for 1970/71 by checking predicted versus actual faculty, staff, etc., by department. This approach introduces a number of problems.

First, actual figures for validation are readily available at the system (campus) level, but are not easily obtained for the department level; i.e., a rather extensive effort would be involved in obtaining faculty and staff position counts and their associated salary dollars. Obtaining operating expense and equipment costs by department is even more difficult. In the near future when the campuses become fully operational under the automated Allotment Expenditure Ledger (AEL) system, actual expenditures by department should be more accessible.

Validation by department offers a second problem. While positions are budgeted by formula, their actual allocation often occurs otherwise. For example, budgeting formulas for the Colleges allow for 0.22 technical/clerical positions for each faculty position. Yet there is no reason to expect departmental allocations for technical/clerical given the departmental budgeted faculty to approach this ratio in reality. In this respect, then, RRPM becomes at times a normative model predicting *what should* be rather than *what is*. All of this can be stated in a different manner: at the campus level resources are budgeted quite quantitatively, but less so for smaller organizational units within the campus.

The other important topic which should be discussed in relation to model validation is faculty work load. One of the input variables of RP is FACLD which is the average faculty load measured in contact hours/week by dicipline and type of instruction (lecture, lab, and other). The California State Colleges basically receive a faculty position for each 12 "weighted teaching units." Essentially, each credit unit that an instructor teaches is weighted by the type of instruction of which that unit consists. Each course in the

Colleges is designated by a code which determines its specific type of instruction, the maximum size the class is to be and its weighting factor for allocating faculty. For example, in lecture situations the weighting factor is 1; i.e., 12 credit hours of instruction result in 12 weighted teaching units (equivalently 12 lecture contact hours give rise to one faculty position). Certain laboratories require three hours of class time a week for one unit of student credit. In this case the designated weighting factor is 2; i.e., 6 credit hours of these labs result in 12 weighted teaching units (equivalently for this type of lab 18 lab contact hours give rise to one faculty position). These are only two examples of the types of situations which can be encountered.

Validation of Instruction Subprogram Cost

For our purposes in RRPM we used faculty load inputs which represent the policy of 12 weighted teaching units (WTU) per faculty position described above. The effects of using policy rather than actual faculty work load figures raise some interesting points with regard to use of the model and its validation. Using policy faculty load in running RRPM leads to the number of faculty positions Humboldt should be budgeted for, not what it actually was budgeted for. The running of RRPM for 1970/71 results in 397 faculty positions as compared to a figure of 348 actual budgeted faculty positions. Although information is not yet available for any quarter of the 1970/71 academic year, information for the three quarters of the 1969/70 academic year indicate that the faculty at Humboldt consistently teach well above the rate of 12 weighted teaching units. If 1969/70 figures are indicative of 1970/71, then the predicted faculty (397) as compared to budgeted faculty (348) is biased in the correct direction; i.e., using higher faculty teaching loads in RRPM rather than policy loads would result in a projected faculty allocation lower than the above 397.

To perform a validation of RRPM, what is obviously wanted is a comparison of predicted costs with actual costs. By using a policy faculty work load, predicted faculty positions and costs are too high to compare with actual costs which are based on 348 faculty positions. How can this source of error be removed for validation purposes?

If actual WTU/faculty at Humboldt were, for example, 13 rather than 12, then using adjusted input data utilizing 13 WTU would result in a reduction of faculty for a run of RRPM of (13-12) (100)/13 = 7.7% which is approximately 30 faculty positions. Knowing generally the distribution of faculty by rank, faculty salary schedules, the staff to support them and its salary schedule, it is possible to derive the overage cost associated with the 30 faculty positions and subtract it from the RRPM run cost for 397 faculty in order to *then* make validation comparisons. The differences then remaining between predicted and actual costs will be due to other sources and random error.

Unfortunately, as mentioned above, WTU information for 1970/71 (our validation year) is not available at this time. It is, however, possible to conjecture various faculty loads, determine the associated average faculty and its cost, subtract it from the base RRPM run, and compare the results to actual cost. These results are tabulated below. The error rates given are for the Instruction Subprogram cost only.

Actual Weighted Teaching Units	No. of Faculty Generated by RRPM	Error[4]
12.0	397	14.4%
12.75	372	7.7%
13.5	348	1.1%

If, in fact, the faculty load at Humboldt is 12, then the model results would stand and the Instruction cost error would be substantial. At the other end, if faculty load is near 13.5, then the number of faculty generated by RRPM would be very close to those actually budgeted for 1970/71 and the error due to other sources would be approximately 1%. The regression coefficients used in these computations were derived from systemwide figures of a previous study. Using systemwide data rather than data specifically for Humboldt expedites data collection but introduces some inaccuracy.

Final model validation for Instruction Subprogram cost will have to wait on 1970/71 faculty load data at Humboldt.

Validation of Support Subprogram Costs

The previous discussion concerning the attempt to adjust faculty positions in order to facilitate Instruction Subprogram cost validation has no effect on validation of the Support Subprogram costs since these costs are evaluated by equations which in general are student-driven or space-driven. A few of the larger cost discrepancies in the Support Subprograms will be briefly discussed below.

The Library area for the Colleges is a difficult area to model. First, numerous budgeting techniques have been utilized in the Colleges over the last few years to determine the various types of Library positions. Second, often positions are allocated differently than the formulas dictate in order to balance fluctuating work loads in various libraries at the Colleges. Thus, the historical data for the number of positions for a library tend to be anything but smooth, making the simple regression analysis inappropriate.

For the Student Support Subprogram Humboldt received an unusually large increase in positions for 1970/71. The linear regression would underestimate such a sudden increase.

Physical Plant Operations Subprogram cost is dependent, among other variables, on the total building space of a campus. Very simply, space can be divided into two gross categories: (1) classroom, lab, office, and study and (2) all of the rest. For the first category, space standards exist and are quite firm, particularly for classroom and lab (space standards being measured in terms of room utilization rate, station occupancy rate, and station assignable square feet). Few standards exist for the second category of space which includes such space-types as museum/gallery, athletic-physical education, recreation, etc.

The validation run of RRPM used actual classroom and lab space factors at Humboldt and some guesses for the factors relating to all the other types of space.

The model was rerun once using (1) CCHE space standards for classroom and lab and (2) some revised estimates of some of the other space-type factors. Overall, space increased approximately 30,000 square feet (roughly 10,000 square feet attributable to classroom, lab, and office and the remaining 20,000 square feet attributable to the other space-types). As a result Plant Operations cost rose $100,000. The point here is that Plant Operations cost is sensitive enough to space so that careful analysis of space and space factors would be beneficial.

Overall, for the Colleges, rather simple linear equations do a quite adequate job of predicting Support Subprogram costs.

C. The Resource Requirements of RRPM

The costs of RRPM to a campus should be considered from several viewpoints: there is the cost of implementing the model as distinct from the cost of using the model after it has been implemented. In both cases costs arise because of the need for resources, primarily in the form of personnel and computer time. The use of personnel and computer time, in turn, involves costs arising because of actual expenditures to acquire additional resources to devote to the model and costs arising when existing resources having other potential uses are devoted to the model. The actual outlay of funds any campus incurs to either implement or operate the model depends then upon the particular mix of these two types of costs encountered.

Individuals with skills in leadership, communication, quantitative analysis, and computer programming are needed to implement and operate RRPM. Programming skills are necessary for processing the input data for the model, to get the programs representing the model running on a computer and to modify the programs as necessary.

Analytic skills are necessary for data acquisition, for understanding what the model is and does, for adapting the model to particular circumstances on a campus, and for interpretation of model outputs. Communication skills are needed in order to work with and involve a broad spectrum of administrators in understanding RRPM and how it relates to the administrative process. Finally, and perhaps most important, leadership skills are necessary to organize implementation, training, and evaluation and to guide the integration of the model within the administrative process.

More specifically, at Humboldt State the implementation effort required about one and a quarter man-years of effort distributed over a six-month period. One member of the project group accounted for one-half of a man-year developing and processing the input data[5], modifying the computer programs, running these programs, and participating in the interpretation and evaluation of the model. The other members of the project group accounted for the bulk of the remaining time. They participated on a part-time basis variously organizing and guiding the project, modifying and interpreting the model and its programs, and taking part in the training and evaluation sessions. Between one and two man-months of the effort was accounted for by the members, primarily administrators, of the evaluation group.

Implementation required about thirteen hours of central processing unit (CPU) time on the CDC 3300. Half of this time was accounted for at the California State Colleges' Southern Regional Data Center in reducing the program's core requirements, testing some overlay schemes, performing the general modifications to adapt the model to a California State College, and to run the model for validation purposes. The other half of this time was at the CSC Northern Regional Data Center and was used to get RRPM running in a communications mode with the CDC 3150 on-site at Humboldt State, to make some additional modifications to the model, and to run the model for training and evaluation purposes. (This latter use accounted for most of the computer usage at Humboldt).

Assuming that some of the learning that occurred on this project is transferable, that good machine-readable files exist, and that the computer time used at the CSC Southern Regional Data Center represented a one-time development effort, it is estimated that three to four man-months of effort and the equivalent of three hours of CPU time on a CDC 3300 would be sufficient to implement (in the sense of getting the model running on a computer with campus data) RRPM on another State College campus. (A computer comparable to the CDC 3300 is minimal for running RRPM).

The use of RRPM on a continuing basis on a campus will require all of the skills discussed at the beginning of this section. It will require a substantial involvement upon the part of one or two individuals on the campus who are intimately familiar with the model and who can serve as interfaces between the model and the administrators involved with planning problems. Computer time will depend upon the extent to which the model continues to evolve (thus requiring modifications to the programs) and how often the model is run. Actual run time for RRPM will require approximately four minutes of CPU time per simulated year (half of this time being used for generating all reports).

III. CONCLUSIONS

1. RRPM can be implemented and run with actual data developed on a State College campus.

2. RRPM has great potential as a planning tool that can improve resource management in higher education. Its cost computations represent an important first step in the difficult task of allocating educational costs back to degree winners, the ultimate outputs of the educational process. Used in a predictive mode, RRPM generates a large amount of information relevant to the planning of both support and capital budgets. Used in a simulation mode it provides a powerful tool for examining the consequences of alternative policy formulations. Additionally, RRPM serves as a very suggestive starting point for the definition of a comprehensive data base on one hand and for the further investigation of phenomena that are not now included in the model itself on the other.

3. If RRPM is to be implemented on a campus, administrators should be fully aware of what implementation at this state of the art implies. The remaining conclusions are addressed to these implications.

4. The administrators, faculty, and students who worked with use on the implementation and evaluation of RRPM at Humboldt State College indicated a concern with the uses to which the model may be put. We share this concern. It involves at least two major problem areas: misinterpretation of the model and the question of who will use it. The possibility of misinterpretation of the model arises in two interrelated senses. First is a possibility of misinterpretation of what the entire model is in concept. *RRPM is not an optimization model. It cannot, therefore, be relied upon to make decisions. It is in no sense a substitute for human responsibility in the decision-making process.* Rather, RRPM is designed to describe resource needs and some of the consequences of particular resource allocations as an aid to the decision-mkaing process. The second possibility for misinterpretation arises in regard to the meaning of the particular outputs of the model.

Many of the data produced by RRPM, especially those describing student costs, have not yet been completely defined in concept. Interpretation and use of these data *in their present form* should be undertaken with extreme caution. The second problem area relates to the question of who will use the model. Decisions concerning the public higher education in general and the California State Colleges in particular are made at three levels: the campus level (local administration), the system level (Chancellor's Office and Board of Trustees) and the State level (Coordinating Council for Higher Education and State government). We believe RRPM has its greatest potential as a campus planning tool used at the campus level. It would, indeed, be unfortunate, therefore, if one of the higher levels of decision making adopted RRPM without providing local campus administrators with the opportunity for participation in the use and development of the model.

5. At this stage, we view the primary potential of RRPM as *motivating a learning process* concerned with the cause and effect relationships that generate and describe an institution's resource requirements. Another extremely important potential of the model is a vehicle for improving the level of communications among the various administrative and legislative levels of decision-making referred to in the previous conclusion.

6. We have no actual forecasting experience with RRPM. Prudence dictates, therefore, that in the early stages of implementation the model be run in parallel with existing planning and forecasting techniques. Thus, users can gradually acquire a feel for how well RRPM forecasts by comparing its forecasts first with those obtained by existing methods and later with the actual observed values of the forecast variables.

7. RRPM is not a static thing but an evolutionary process. At this stage of its development it would be fruitless to estimate a version of it and simply make it available for administrative use. Instead, wherever the model is implemented, responsibility for its maintenance, interpretation and further development should be assigned to an administrative unit which has access to personnel possessing both analytic and programming capabilities. Based upon the experience at Humboldt State College it is strongly recommended that, at least during the implementation stage, a single individual be assigned full-time to the task.

8. The benefits of the evaluation process to the management evaluation group were (at least):

   1. Increased knowledge about this college and how it operates.

   2. Insight into the interrelatedness of the various programs, subprograms, and impact of decisions.

   3. A better understanding of the models in higher education, the WICHE NCHEMS program, and the security gained through knowledge.

IV. FUTURE DEVELOPMENT AND USE OF RRPM

The use and feasibility of RRPM, the ICLM, and models in general have been considered by Humboldt State and the Chancellor's Office. RRPM and the ICLM are up and running at Humboldt State. The management group at Humboldt State has gone on record as being in favor of utilizing these tools. Interest in systemwide application centers in the Division of Analytic Studies in the Chancellor's Office.

Certain steps need to be taken to place RRPM in an <u>operational</u> mode at the Humboldt campus:

1. Some simple documentation needs to be completed.

2. Decision forms for RRPM to be used by campus administrators need to be developed.

3. The structure and procedures for the use of a planning model need to be designed and installed.

4. A capability to work with analytic tools for decision-making needs to be built into the organization.

5. Adaptation of the changes being made by NCHEMS in the college version of RRPM in response to the pilot test experience.

V. EPILOGUE

We have found the task of pilot testing RRPM a rather unique and, for that reason, a rather exciting experience. The existence of an analytical planning instrument in education being utilized at this time is undoubtedly rare. We are just on the frontier of an era of new management tools for educational administrators.

We seem to be, at last, moving from the often discussed theory to the often alluded to notion of implementation. The last six months have indicated that there are many problems in gathering data, testing, and implementing an RRPM, but the resulting involvement of management as evidenced by its dialogue (constructive as well as destructive) is a reward worthy of the effort.

The obvious danger at this point lies in the tendency to relax, to "rest on one's laurels," to assume that RRPM will magically continue to function on the impetus given to it in the last few months. We feel that more effort must be exerted to make it an ongoing affair. This is the direction in which we are continuing to exert effort and influence.

REFERENCES

1. On site of CDC 3150 (16K words memory) and telecommunications to the California State Colleges Northern Regional Data Center in San Jose (CDC 3300 112K words memory).

2. A group of about 25 key administrators, faculty, and students that meets with the College President about every two weeks.

3. Mr. Keith Evans, Office of the Vice-President of Academic Affairs, University of Michigan. In addition to representing the University at NCHEMS, Mr. Evans was conducting a study of the eight pilot schools for NCHEMS and an independent study on decision-making in higher education.

4. Error is computed as

$$\frac{\text{Predicted Cost-Actual Cost}}{\text{Actual Cost}} \quad X \quad 100\%$$

5. This does not include development of an ICLM which was already available at HSC.

III

SUMMARY OF RRPM IMPLEMENTATION

AT NEW MEXICO JUNIOR COLLEGE

K. M. Hussain, J. Shepherd and D. S. Stuart

1. Introduction

The pilot study in New Mexico was sponsored by three organizations: New Mexico Junior College (NMJC) that had the data and top administrative support; New Mexico State University (NMSU) that had the computing system and contributed Dr. Hussain's services; and finally, the State Board of Educational Finance that contributed some financial resources and much of the initial motivation.

The pilot study at NMJC was completed according to the specifications of the contract by the specified date of June 20, 1971. This study has four main sets of activities: data generation; special projects; model testing; and orientation and training. Each will be discussed and followed by an analysis of costs, a set of evaluation comments and some conclusions.

2. Data Generation

Much of the data for RRPM-1 had to be created from "scratch." This required the design of one new file, the Student Course Record File; the redesign of two existing files, Classes Taught File and the Personnel File; and the manual generation of many of these coefficients (especially on Space and Finance).

Standards were set up for report generation. These included:

2.1 All data elements used in the files are to be compatible with the Data Element Dictionary issued by WICHE.

2.2 State Files must be used as much as possible so that the programs for data generation can be used by other institutions in the State. In the case of new files, the programs to be written for data generation are to written so that they can be used on an inter-institutional state-wide basis. This will reduce the cost of data preparation by other institutions in New Mexico if they desire to use the RRPM-1.

2.3 All programs are to be written according to standard program specifications stated in the job specifications.

2.4 All data generation design and programs are to be fully documented, including keypunch instructions. This is essential because the design is to be done at the NMSU campus and the input for the files are to be collected at NMJC, located at Hobbs. The ability to communicate in a spatial sense would be useful later when the documentations are used by other institutions in the State.

2.5 The PM-1 input data should be listed and other reports generated to facilitate the checking of the data.

2.6 All input is to be checked by validity programs before the reference reports and PM coefficients are generated. The PM-1 input tape, once generated, is also to be checked for validity to be sure that the data meets the specifications of the PM-1 input tape, but this would be done by the Pre-Processor, a subject outside the scope of this package.

2.7 All crucial totals are to be compared by one or more of the following methods:

2.7.1 Against another total in the file or another file in this package.

2.7.2 By other programs using the same data file.

2.7.3 By persons knowledgeable of the coefficients.

In the case of checking programs, the programs were written by another programmer and in another language in order to overcome problems of systems design, programmer interpretation and language peculiarities.

The checking is to be done by persons at NMJC who are knowledgeable of the data.

2.8 All file packages must be documented according to standards as displayed elsewhere.

2.9 Features of Each File

2.9.1 Validity test of input
2.9.2 Listings of RRPM coefficients for each major
2.9.3 Plots of coefficients for RRPM for each major
2.9.4 Comparison of coefficients for RRPM for one year
2.9.5 Comparison of coefficients longitudinally for > 1 year
2.9.6 Other related analytical reports
2.9.7 Control totals
2.9.8 Documentation according to stated specification
2.9.9 Test of file by back-up programmer

Data from the input files was checked for validity by having Divisional Chairmen and the Vice-President for Instruction check their respective files. The main purpose of the data generation project was to create data to run the RRPM-1. There were, however, numerous by-products. It unearthed practices that were wrong and unknown to the administration; it trained personnel in data processing; it identified data at the department level that proved revealing to the divisional chairmen and Vice-President for Instruction; and it provided a data base for generating numerous other reports that will be valuable to the administration. One of these is the study of the stability of the Induced Course Load Matrix generated by the Student Course Record File, a subject discussed below.

3. Special Projects

There were two sets of special projects. One was requested by the contract with NCHEMS. The other was considered necessary by the NMJC. These are:

3.1 Required by NCHEMS

NCHEMS required the design and programming of two partial Pre-Processors (1 and 3). It recommended another, partial Pre-Processor 2. All three were completed according to the specifications and dates stated by the Task Force. The Partial Pre-Preprocessor 2 was a set of analytical reports for any one year. The reports were extended to include a longitudinal analysis of selected variables.

3.2 Required by NMJC

There were three special projects: longitudinal study of ICLM, development of a TRACER-TRAINER, and the terminal implementation of RRPM. These are discussed briefly:

3.2.1 ICLM

The sensitivity of the model to the ICLM was recognized and the importance of a stable ICLM for prediction was also recognized. Accordingly, a special project to study the stability of the ICLM at NMJC was initiated. A weighted average method was used and the Fall and Spring ICLM's were aggregated to find the most stable ICLM.

3.2.2 TRACER-TRAINER

This is a routine that traces each set of computations of the RRPM for any selected discipline identifying any input as it is used. The output can then be used both for training faculty in the computations of their disciplines and in tracing errors caused in the computations of certain disciplines.

3.2.3 Terminal Implementation

Because of the distance of NMJC from the processor (250 miles and a slow mail service in between), it was considered desirable to implement RRPM on the terminal. This has been accomplished. It operated on CRBE and is not on-line but it does reduce the turn-around to overnight. For special occasions, such as training seminars, the computer system can be dedicated and the turn-around greatly reduced.

4. Model Testing

Historical data was used for the three years (1968-70) for which any data was available. For these years, model predictions were compared and plotted on control charts using ± 10% as the control limits. One point (Financial Aids in 1969) was "out of control" but "explained" by special circumstances and, hence, considered not a significant discrepancy. The predicted overall budget for each of the three years was within ± 5% of the actual budget.

5. Orientation and Training

The orientation consisted of one lecture to all faculty and two seminars for the analytical team at NMJC. Also, the MICRO-U game was modified and used with NMJC data. It was "played" by over 70% of the faculty and 80% of the administrators at NMJC. The participation was voluntary, indicating the high level of involvement. The game was also "played" by Presidents and Vice-Presidents of institutions of higher education in New Mexico.

Training on RRPM-1 output was postponed until after the model was validated. Dates for such training have been scheduled for Fall 1971.

6. Costs

The out-of-pocket costs for the study were $40,123; indirect service costs were $58,627. The costs are higher than they would be in many other institutions because of the following reasons:

6.1 Two hundred fifty miles separated the institution where the data was collected and the institution where the data was processed. This separation required many phone calls, many journeys by personnel from both campuses, inefficient use of personnel retained for the project on the two campuses, and a considerable amount of extra coordination.

6.2 The distance also meant a loss of time in travel. There were 41 passenger trips, with roughly 1/6 of a man-year spent in travelling; this was mostly middle management time.

6.3 The additional related studies performed (e.g., longitudinal study on the ICLM, the TRACER-TRAINER and the terminal implementation).

6.4 The thoroughness of documenting and testing the files.

6.5 The version of RRPM-1 changed to version 2 which required redesigning one file completely (personnel) and another partially (classes taught).

6.6 All staff for the RRPM-1 had to be selected, hired and trained in administrative data processing. In some cases, students were hired and trained as programmers. Similarly, the data preparation clerk was hired and trained on the keypunch and data collection. Secretaries were also trained on the job. This training was expensive compared to an institution that reassigned its personnel to the RRPM-1 using a matrix organization concept of project management.

6.7 The cost shown for NMJC may seem larger than at other pilot institutions partly because it included more items of cost. Also, it is completed with no loose ends and fully documented, including the documentation of the data files.

6.8 This implementation was not just for one institution but a pilot for the State of New Mexico. Thus, most of our activities were more expensive, e.g., our training involved two MICRO-U seminars for state-wide administrators.

7. Evaluation

All involved in the project (users, developers and financiers) considered the project worth its cost. There were many unexpected by-products of the RRPM such as:

- it revealed data on institutional characteristics that its management was unaware of
- it provides a data base that can be used for institutional studies not otherwise possible
- it "involved" management in a formal long-range planning and introduced concepts and approaches hitherto unknown to management
- it made management want a comprehensive management information system
- it has forced management to analyze and define its institution in a formal way

- the simulation aspect of the model forced management, especially middle management, to consider trade-offs and appreciate interrelationships.

8. Conclusions

The implementation of RRPM-1 at NMJC is a good case study in feasibility and success of a management information system implementation. The success was not due to sophisticated equipment (NMJC borrowed equipment 250 miles away); it was not technical personnel at the institution (all were hired specifically for the project); and it wasn't a good data base (most of the data was created for RRPM-1). The success in the last analysis was due to top management support, both at the state level (Dr. W. McConnell and Dr. D. Stuart, Board of Educational Finance) and at the institutional level (Dr. J. Smith, President, and John Shepherd, Vice-President for Instruction).

IV

SUMMARY OF RRPM IMPLEMENTATION

AT PORTLAND STATE UNIVERSITY

R. Low

(Not available at time of publication,
will be distributed at a later date.)

V

SUMMARY OF RRPM IMPLEMENTATION

AT STANFORD UNIVERSITY

A. Dermant, M. M. Roberts, W. E. Witscher

I. SUMMARY

In March, 1970, Stanford was invited to participate in the NCHEMS RRPM Pilot Test project after an evaluation by the Center staff which indicated that the input data requirements for the model could be satisfied at Stanford, and that the university was representative of the characteristics of many private institutions in the United States.

Because of its commitment to the NCHEMS program as a Level IV participant and because of a pre-existing effort directed at development of an institutional model, the invitation was accepted, although it was recognized that participation would place a significant burden on a heavily loaded professional staff. See Section II of this report for further background detail.

Activity at Stanford during the pilot test can be separated into three major phases: (1) Making the RRPM computer programs operational at Stanford, including code debugging, corrections, test runs, and revisions to keep current with programming activity going on at NCHEMS; (2) Defining, collecting, and interfacing Stanford data to the RRPM computer programs; and (3) Evaluating the results of operational runs of the model. In addition, Stanford participated in Task Force meetings at which a variety of conceptual and operational problems were discussed and resolved. A chronology of major pilot test events is included in Appendix B.

The predicted results for instructional FTE and cost for the current year, 1970-71, based on data from 1966 to 1970, did not come within acceptable limits of accuracy as compared to amounts budgeted for 1970-71. The predicted instructional costs ranged from -2% (best) to +182% (worst) with an average variation for twenty departments of 60%. The primary reasons for the large differences were the following:

(1) The actual accounting data which was used contained, in many cases, one-time expenditures not directly related to instructional activity measures, and this procued unreliable regression coefficients. Additionally, there are deficiencies in some of the data from earlier years which added to poor predicted values.

(2) RRPM is basically an enrollment driven model, in which faculty FTE requirements (the primary component of cost) are derived from matching student course load projections against static ratios of average class size and faculty teaching load distribution by rank. In many Stanford departments, because of the high ratio of senior and tenured faculty and other factors, variations of student course demands are met through adjustment in class size and/or teaching load, rather than through adjustment in faculty FTE. The resultant variability in class size and teaching load values obtained in the execution of RRPM produced additional instability in the predicted results.

In view of the foregoing, it cannot be stated that the Stanford pilot test represented a successful implementation of RRPM. However, a very substantial amount of knowledge in building and use of models has been gained by the members of the university RRPM team, and it is intended to use this knowledge and modified RRPM software in coming months to continue development of a cost model of the university. (See Section IV for further detail).

II. BACKGROUND

Like many other universities, Stanford underwent a period of explosive growth during the 1960's. Initiated by a successful five-year, 100 million dollar fund raising campaign, this surge of growth was sustained by an extraordinary increase in federal sponsorship of research and training programs. During the decade, operating expenditures tripled to $129 million, faculty membership in the Academic Council nearly doubled to 1,031, and student enrollment rose 32% to 11,600. Many new academic programs, including several overseas campus locations, were initiated; a number of academic specialties achieved full-fledged departmental status; new administrative services, such as radiation control, were required. During this period, a new attitude questioning the direction of higher education arose, at first largely student generated, but increasingly echoed by society at large.

Responding to the new pressures created by rapid growth and by calls for reform, President Wallace Sterling (now Chancellor of the University) proposed and set in motion, in 1967, a Study of Education at Stanford (SES). The following excerpt is from the November 1968 transmittal letter of the Steering Committee of the SES:

> "A university, above all other social institutions, should engage in a continuing process of self-examination and self-renewal. To a surprising extent universities have failed to do so. On as mundane a level as the routine collection of information about what goes on in the University, we have found astonishing gaps . . .The study of education at Stanford must become a process rather than merely an event."

One of the principal early recommendations of the SES Steering Committee was that the university establish an academic planning office to collect and analyze the data required for intelligent planning and resource allocation, which was accomplished on a pilot basis in 1969-70, and as a regular effort in 1970-71.

Although the financial analysis staff at Stanford has prepared and issued a ten year financial forecast for a number of years, antedating many other schools in this regard, the financial plan has focused primarily on growth rates by major categories of income and expense. The shortcomings of this non-programmatic procedure have become increasingly apparent as costs continue to grow at a significantly faster rate than income.

These two somewhat different streams of interest in data collection and analysis were melded together in an ad hoc group formed in 1968 and composed of Messrs. Raymond F. Bacchetti, Associate Provost and subsequently appointed Director of the Academic Planning Office, Franklin G. Riddle, Director of Financial Planning and Analysis, and Michael M. Roberts, Director of Administrative Computing. The early deliberations of this group focused on potential contributions of modeling, and were assisted in this regard by Professor Norman Nielsen of the Graduate School of Business, an authority on simulation. However, it rapidly became apparent that the "what if" questions to which models address themselves needed to be preceded by a "what is" effort aimed at collecting comprehensive and analytically valid data on the variety of academic activity measures necessary to present a picture of what is going on in the university and to serve as input to any model that might be developed. The balance of 1968 was devoted to this effort, which was principally supported by Mr. Andre Dermant, Analyst with the Systems Development Group, and by Mrs. Sarah Main and Mrs. Cindy Gilbert of tne Academic Planning Office.

In the context of Stanford's internal developments, the NCHEMS invitation to participate in the RRPM pilot test came at a propitious moment, for it offered the opportunity to acquire potentially very useful modeling software without the substantial costs of inhouse development, as well as gaining an insight into how useful such a model might be for assisting resource allocation decisions, both at Stanford and at other institutions. With the initiation of the pilot test, Mr. Roberts became the task force representative and project coordinator, directly and energetically supported by Mr. Dermant and by Mr. William Witscher of the Financial Analysis section. The Stanford management team additionally included Mr. Riddle, Mr. Kent Peterson, Manager of Analytical Studies, and Mr. Kenneth Creighton, Deputy Vice President for Business and Finance.

III. MANAGEMENT EVALUATION

A. Introduction

The operations of a modern, private university are extremely complex; both from the standpoint of the instructional and research activities conducted, as well as in the sources of support for these activities. When this complexity is coupled to the rapid rate of change characteristic of our society at this time, the resulting environment is a dynamic one, in which planning horizons shrink, and previous resource allocation procedures become less and less useful, particularly in the presence of declining levels of support from external sponsors relative to internal increases in program support costs. In nearly all private schools and many public ones, the financial squeeze has contributed to a trend toward more centralized decision making in the resource allocation process, and institutional managers have found themselves poorly provided with analytical and evaluative information on which to base such decisions. Further, there has been slight or no capability to project the consequences of current decisions into the future in other than the most aggregate fashion.

As has been pointed out elsewhere in the literature, the principal remedies for this problem involve the collection of comprehensive and accurate data, the definition of an analytical framework, and the use of tools, such as models, within the framework. The RRPM pilot test represents the first real effort to follow through these steps, and has provided a major learning experience for the financial analysis and budgeting staff of the university.

It is the conviction of the Stanford team that this report would be more meaningful and useful if it were to be written a year from now. Although much has been learned, the results to date are inconclusive. As mentioned in the summary and detailed in Appendix E, the predicted values for the 1970-71 year were substantially at variance with the amounts budgeted for the twenty departments used in our pilot test, for a variety of reasons. Rather than pursue further refinement of pilot test data, it was decided to conclude the pilot test, after some thirty iterations of the model, and drop back into a design mode in an effort to make basic changes in the operation of the model which would allow it to produce accurate and useful predictions. Some of the specific problem areas and the solutions proposed (but untested at the time of the writing of this report) are enumerated below and in Section IV.

B. Analysis of the Model

It has been generally recognized (see NCHEMS Technical Reports on RRPM-1) that the model would be more flexible and accurate if it were driven by output from a student flow model and a faculty flow model, and both of these projects are under development by the Center. In their absence, a series of fairly deterministic assumptions are made in RRPM-1 that created problems in producing accurate predictions. For instance, average class size is calculated based on current enrollments by level of course (and type of instruction - which was not used in the Stanford test) and this ratio applied to future increases (decreases) in discipline enrollments by level without regard to whether, in fact, the class size would be allowed to grow or shrink rather than adjusting the faculty workload. While in a large undergraduate college this might be a reasonable simplification, at Stanford the average class size university-wide is less than twenty-five, and variations in class size of one hundred percent often occur without any adjustment of faculty assigned. Similarly, RRPM calculates the number of faculty required (which is the primary component of instructional cost) by taking the product of current workload, as expressed in weekly contact hours, times the calculated number of classes required to support projected enrollments. In practice, Stanford faculty members frequently adjust their workload by adding or dropping a course to meet demand for classes on a very short term and dynamic basis.

The Induced Course Load Matrix (ICLM) was found to be most useful for producing future discipline course loadings. However, we were unable to measure its stability over time, and this is a critical element in the operation of the model. The evidence available in the form of course enrollment statistics indicates that there are substantial changes taking place in enrollment patterns, and the model needs to take account of these changes.

RRPM ignores the interaction of some elements within the model--more precisely undergraduate units and graduate student teaching effort. If an increase in undergraduate enrollment is predicted and no change in graduate enrollment, RRPM will indicate that an increase in graduate student teaching effort (and cost) is required. Since graduate students have not increased in number, this means those at the university must teach proportionately more. The obvious result is that they, in turn, take fewer courses (not calculated by the model) and stay at the university longer--which, in effect, increases graduate enrollment or forces the university to admit fewer graduate students. Therefore, for the model to be accurate, the input of changes in undergraduate and graduate enrollment must be proportionate, or the decision makers also have to input manually all the modified values for DIVCO by discipline, and by year of forecast. The treatment of DIVCO (faculty by department rank) is questionable since it assumes a casual relationship between rank distribution and students and courses which we have found difficult to demonstrate. Such things as appointment, promotion and retirement policies and schedules are thought to affect DIVCO more than courses or students.

The above comments on operation of the model are not made with the intent of diminishing its potential value, but rather to point out that simplifying assumptions may have a serious impact on specific institutional environments, such as found at Stanford. If an institution has never worked with its academic activity data in an analytical framework, then RRPM is an excellent way to make a start. Future programmed improvements to it will eliminate or reduce the difficulties associated with most of the current assumptions.

C. Evaluations by Stanford Team

Statement by Deputy Vice President, Kenneth Creighton

> "The need for careful planning and analysis has risen very rapidly in the last few years and I see no diminution of that trend. As we apply our staff resources to problems of increasing variety and complexity, it is important that we use every analytical tool available that promises a better answer with less effort. I believe that the RRPM pilot test, which was our first acquaintance with a large model, to have been worth the time and effort expended, even though the results are disappointing in terms of their immediate utility to our budget group. I look forward to the promised refinements in its operation, both because of their ability to give a more detailed look at the future and the consequences of current budgetary decisions, as well as the insight

they will provide into interrelationships among the key variables in our academic "mix," students, faculty, and their associated costs."

Statement by Manager of Analytical Studies, Kent R. Peterson

"Based on our work with the RRPM model this spring and summer, I would not foresee us using this particular model in the immediate future to review decision alternatives.

The basic problem is that this general model does not "fit" Stanford closely enough to use for resource requirement predictions without some major changes. One of the major problems is the research component of the model. A useful resource requirement prediction model for Stanford would probably have the research component driven by the research backlog and similar data which we have available, rather than historical data.

Another problem is the extent to which the model is "student driven." At Stanford, future resource requirements by department are dependent, to some degree, on student flow, but there are other variables which also have an impact on resource allocation.

In conclusion, the current RRPM model would require some major alterations to be used as the general model for predicting resource requirements at Stanford."

Statement of Director of Financial Planning and Analysis, Franklin Riddle

"My prinicpal concerns about the use of RRPM revolve around the fact that although not a simple model to collect data for and operate, the level of detail does not represent the instructional process at Stanford adequately enough to be used for future planning and allocation at this time. Stanford is no longer a growth university, our future estimates foresee essentially stable faculty and student headcounts, and it is likely that such parameters as class size and faculty workload will be adjusted to fit prospective funding levels, rather than that additional funds will be available for expansion.

I believe that we will, in the short term, be developing a number of small single purpose models which house enough variables to give reliable and specific answers to carefully phrased questions, and whose data and programming requirements are far less than those of RRPM.

I recommend that we continue development of an instructional cost simulation model, but under a fairly intensive level of managerial scrutiny so that our commitment does not involve us in major expenditures of money for support of the model until we have good evidence of its accuracy and utility."

IV. FUTURE PLANS

Given the shortcomings of RRPM pilot test output as discussed in Section II above, a meeting of the Stanford team was held in early July to discuss future use of RRPM at Stanford.

There was general agreement that a valid cost model for instruction, including such activity measures as departmental enrollment projections and faculty course loads, would be of considerable value for planning purposes. However, before a decision could be made to implement such a model, additional development would be necessary to demonstrate that the model could predict values with greater accuracy than those produced by RRPM-1 (version 1.2) with pilot test data.

Principal proposed changes in procedure from the pilot test were:

(1) Eliminate the use of regression and historical data except in isolated cases and in such cases analyze the data by hand outside the model. Substitute cost coefficients based on current information and policy in lieu of those developed by historical regression.

(2) Change the source of data from historical accounting record to what is known in Stanford parlance as the departmental "budget base", which is considered, on the basis of the pilot test experience, to have a closer relationship to instructional activity.

(3) Review the differences between effective faculty FTE in instructional budgets as developed from payroll records, with actual teaching faculty FTE as measured by course load data contained in student files, to determine which is the better measure for cost simulation purposes.

(4) Investigate the software problems involved in allowing class size and number of sections to be dynamically variable during operation of the model, so as to reflect more closely the actual adjustments in these variables which occur as departments deal with varying class enrollments.

(5) Review the extent to which, if at all, support costs should be allocated to instruction as part of the operation of the model. General and administrative expenses are relatively independent of instructional activity measures, and are usually budgeted based on needs other than those represented by instruction. (Direct instruction costs are only one-sixth of the total budget.)

It is planned to conduct a test of these new procedures on revised data from one or more departments during the next six months. Results of the test will be evaluated in terms of potential contribution to Stanford's resource allocation procedures prior to setting in motion routine data collection, analysis, and running of the model. During this period, contact will be maintained with NCHEMS staff engaged in follow-on development of RRPM.

It should be noted that the Stanford evaluation saw little benefit, at this time, in attempting a "total" cost simulation, including such components as space and research in addition to instruction. Again, the primary reason for this is that major academic space and research decisions are the result, in the private institution, of processes not directly linked to instruction. It may, over time, be of interest to attempt analysis of these areas for the purposes of simulation, but such projects do not currently command a high priority.

VI

SUMMARY OF RRPM IMPLEMENTATION AT THE STATE UNIVERSITY OF NEW YORK AT STONY BROOK

D. L. Trautman

1.0 CONTEXT, EXPERIENCES AND OUTCOMES OF THE RRPM PILOT TEST

1.1 Overview

Stony Brook, as a public institution, derives is support from the New York legislature through an annual budget process involving State University of New York Central Administration (SUNY), the Bureau of the Budget, and the Governor. All parties are intensely interested in the outputs and inputs of the academic enterprise and an understanding of their interrelationships on which operational decisions could be based. Development of data systems and simulation models would appear highly relevant to this need.

The Resource Requirements Prediction Model (RRPM) is an elaborate computer program based on the cost-simulation model of George Weathersby as modified and extended by Mathematica, a Princeton consulting firm, and by the WICHE staff in collaboration with the eight Pilot Test institutions. It provides calculations of instructional workload, faculty, staff, expenses and space, based on externally provided enrollment projections and institutional data concerning instructional and administrative processes. More than separate resource calculators, it ties together and interlocks budgets of all parts of the institution. That is, by means of the Program Classification Structure, partially implemented, it provides a framework for viewing the institution as a whole. It requires an internally consistent and somewhat comprehensive data base and an analytic formulation of resource utilization processes.

Because of its comprehensiveness, RRPM promises to be a substantial stimulation to an understanding of institution-wide administrative processes and a prod to develop and refine an appropriate institutional data base. The RRPM paramenters, variables, modes of calculation and reporting formats are congruent enough with those of SUNY as to provide a potentially useful modeling tool. (But see later comments for certain difficulties.) The indirect salutory effects on the quality of decision making attending model developmental work can be substantial, quite apart from the potential impact of the ultimate use of the model in administrative processes in the future. The RRPM Pilot Test activity followed the initial development of Stony Brook resource calculators for student workload, faculty and space, and was concurrent with development of student flow models and preliminary running of CAMPUS V. In parallel also was a separate development of an MIS group and refinement of the transactional data base.

All these efforts have yielded a certain success, many expectations have been fulfilled, and it is clear that all efforts aid and abet each other. It is also clear that the process of implementing a model such as RRPM is a long-term effort. But a direction has been charted and a beginning has been made in introducing the potentialities of modeling to persons in various administrative posts. Stony Brook is encouraged to tackle the next stage of providing a Stony Brook modification of RRPM 1.3 which would incorporate the best features of the several models under test and would reflect more realistically the actual operational features of Stony Brook's resource budgeting and planning. With these revisions, the next stage of training sessions for users would begin. It is contemplated that component modules (enrollment forecasts, student workload, faculty, space) would service some users and the full RRPM system integration would service others. Only after these developments will Stony Brook have sufficient experience realistically to indicate potential impact of models on its administrative processes.

1.2 Efforts

As a follow-up to general endorsement of Stony Brook participation in the RRPM Pilot Test activity the President's cabinet formed a Task Force comprised (in part) of themselves or their representatives. The Office of Long Range Planning undertook project and technical responsibility, and worked closely with the offices of Management Information Systems and Administrative Data Systems (Computing Center), and all had representatives on the Task Force. An initial meeting in February 1971 revealed (a) lack of readiness of RRPM to receive data, (b) hesitance of offices to set high priority to supply (specialize) data and (c) a questioning of the worth of the end product. That is, bearing in mind the impression that important university decisions were not being made because of sociological constraints, the potential of a new data tool was certainly not of keen interest.

The character of Task Force discussion during six subsequent meetings (April - June) therefore dwelt heavily on the potential worth of models for resource planning and budgeting, and (later) on actual inputs and outputs of RRPM. Because of the varied background of members of the Task Force the RRPM discussion was focused at the campus budget level Conferences were held with individuals for the purpose of discussing technical details and to elicit their specific reactions. Although the direct involvement of the Task Force with RRPM implementation did not develop, its deliberations were very helpful. Furthermore, the Task Force will now provide a core group for training and future use of RRPM.

On the technical side, the RRPM Pilot Test fit into Stony Brook's ongoing effort devoted (a) to computerizing its data base and (b) to calculating resource allocation parameters such as student/faculty ratios and support costs, and (c) to exploring elementary system simulators of resource allocation in the instructional process using a typewriter terminal and an IBM 360/67 computer. Therefore, Stony Brook welcomed the opportunity to participate in the new WICHE co-operative implementation of RRPM as an example of a more comprehensive system simulator.

High levels in the Administration and faculty ranks backed the effort and the University expended an estimated $43,000 in direct costs and $18,000 in specific indirect costs (exclusive of general computer overhead). This included eight cross-country trips to attend WICHE meetings and the hiring of two systems analysts/programmers. Not included in this estimate is the substantial on-going effort to improve the institutional data base which was further stimulated by RRPM. A continuing contribution was made by the WICHE staff through its Task Force and Technical Workshop meetings, its in-house revisions of the RRPM computer programs and the consulting visits of its staff. Some 18 calendar months were required but one year should suffice for implementation of an already developed model and an already computerized institutional data base.

Other institutions, in implementing RRPM should count on all these effort-inputs as a minimum, and add an important ingredient not possible during the Pilot Test: execution according to a well-conceived plan based on comprehensive pre-analyses and full (de-bugged documentation.

1.3 Major Tasks

In retrospect, the tasks of implementing RRPM fell into seven major groups, although in the developmental pilot test actvity they could not be preplanned nor clearly separated, and for new implementation programs their weighting would be different. These major tasks were:

(a) debugging computer programs, first those provided by Mathematica (version 1) and then those provided by the WICHE staff (version 2). Although version 3 (to be released) will have been debugged and the documentation will be complete, new institutions may make some programming changes to adapt RRPM to their specific needs. If so, ample effort should be devoted to assuring correctness of all modified programming. (15%)

(b) providing an adequate descriptive data base traceable to a minimum number of self-consistent prime sources. This task should not be underestimated, nor can it proceed independently of development of the normal operating files of the institution in machine readable form. (25%)

(c) representing resource allocation processes in equation form (so-called estimation equations). An in-depth study of the library provided little keener insight than eye-balling budget trends or simply describing intended processes. However done, the functions of all major units must be understood and a judgment made of how to represent their future or desired functioning. (10%)

(d) preparing all data for use by RRPM. Stony Brook had much of its instructional data on tape and so wrote conversion programs to yield RRPM parameters and formats (some of which proved awkward). This approach minimized the use of manual data collection and keypunching, but the large time required can be justified only by repeated use of the tapes and conversion programs. (20%)

(e) validating the model in terms of institution operations, a very critical task which invokes considerations of important variables, levels of aggregation, sophistication of estimation equations, mode of calculation, time span of projection and general questions of use. This was not adequately completed and until it is, the usefulness of RRPM at Stony Brook is limited. (20%)

(f) introducing the model to administrators and its use in university processes. Ideally, this should begin early with the use of WICHE test data so the capabilities of RRPM can be well understood. A good beginning has been made but until validation is completed no forthright progress can be made. (10%)

(g) determining cost effectiveness of each variable in RRPM. This special task centered on the overall process from data capture through processing to actual use in decision making. Much depends on the particular institutional situation. (10%)

1.4 Observations, Limitations and Suggestions

(a) The generalized budgeting task can be viewed as generating resource requirements for all functions (automatically) through knowledge of their underlying processes. Short-term and long-term budgeting and planning blend into a common activity. In short, the useful model must have a continuous time control from present to planning future, and be directly related to the objectives and procedures of the institution.

(b) The potential worth of modeling tools in university resource management is difficult to determine without actual experience with them.

(c) It is useful to distinguish two classes of data in terms of capture and processing:
   (1) attribute, status or state data, such as headcount, or dollars,
   (2) data on processes which lead to equations and their coefficients to link data groups (so-called estimation equations).

(d) Difficulties with data arose from incorrect reporting, changing definitions (over the years) and inconsistent source documents. Some RRPM data requirements were in different form than in general use at Stony Brook.

(e) Adjusting the model to the institution is a complex process because of the number of significant variables and levels of aggregation. The organization of RRPM is fixed (enrollment driven) but estimation equations and mode of calculations can be adjusted. Validation, therefore, can become a very time consuming task, and it should be planned systematically.

(f) The RRPM may be considered part of the combined data base and its processing available to decision makers. It is difficult to relate the effectiveness of the decision to the cost of the data. The former is sociological and is time dependent whereas the latter is highly variable over different kinds of data and depends on whether the desired data is a part of the conventional data base. Generally speaking, the decison maker always needs more data, although non-perfect, so long as its characteristics are specified.

(g) The model parameters subject to control may be different at each organizational level (e.g., class size is set by the faculty but the president negotiates an overall student/faculty ratio). RRPM only indirectly addresses this situation.

(h) Parameter arrays (such as the Induced Course Load Matrix) run the risk of introducing error when aggregated and used with a vastly different distribution of inputs.

(i) The HEGIS disciplines do not correspond to Stony Brook organizational units and therefore are not convenient to use for campus applications.

(j) Stony Brook budgets assign personnel to a single organizational unit and not to a smaller function than the one in which the whole unit is located. Therefore, full and correct use of the Program Classification Structure is not possible. (e.g., activity split between instruction and research).

(k) Report formats should (1) sumarize input data and run conditions of RRPM and (2) separate the output data into controllable and uncontrollable portions (a form of exception reporting).

(1) Report entries and format should be aligned to Stony Brook usage (e.g., include graduate student support and equipment depreciation).

(m) Programming should permit operating RRPM in modular form so that experimentation can procede with a single resource, such as space.

(n) Implementation of RRPM should not be hurried, yet the effort should be continuous and at the level of at least two FTE professionals.

As a caution, as model capabilities are further developed and explored the user (a) must avoid the false security that numerical representation constitutes fact (devoid of socio-psychological and judgmental elements), and (b) he must avoid the temptation to rashly compare activities because their data formats are similar (thus overlooking essential guidelines for comparability).

2.0 TECHNICAL FEATURES OF THE RRPM PILOT TEST

2.1 Description of Stony Brook by RRPM Data

The resource requirements of the entire institution are calculated by RRPM primarily on the basis of inputted enrollments, patterns of course selection and patterns of faculty staffing, and indices of salary and space. Secondarily, ancillary personnel and support dollars are determined via estimation equations which link them to enrollments and faculty. Most calculations are carried out on a discipline (or department) basis, at certain levels of disaggregation (such as course level or faculty rank) and in definite order of forming subtotals. Some flexibility exists for the institution to supply its own dimensions and alternate forms of calculations, but other desirable changes in the model might require substantial modifications to the program.

Many decisions of obtaining and distributing resources at Stony Brook are based on student/faculty ratio, various faculty workload measures and support costs. In addition, graduate student teaching and research assistant support come respectively from the faculty and support cost budgets. Hence these additional variables are needed to yield a more helpful data description of Stony Brook. Furthermore, ancillary personnel are perhaps better determined on a more aggregated level than Department. Finally, Research and Public Service programs require inputs independent of Regular Instruction. RRPM has not been so modified.

The chief message here is that the data (parameters and variables) and interrelations among them which are selected to describe the institution must relate to the actual functioning of the institution and to the uses to which the description and its projections will be put. This should be examined carefully prior to implementation of the RRPM model. Otherwise validation will be difficult or impossible and use will be severely limited.

2.2 Data Sources

Three comprehensive data sources sufficed to operate RRPM at Stony Brook:

(a) records on "instructional equilibria" from the registration student class card tape and from the faculty course assignment tape. (These are combined more-or-less in the "Schedule of Classes" file).

(b) abbreviated budget records on a departmental basis.

(c) indices such as salary scales and space guidelines.

The first is by far the most comprehensive and fortunately is obtainable on tape in the most disaggregated form possible (and desirable) --by discipline course, level, type, enrollment, credit, hours, rank, etc. The chief difficulties with this data were poor reporting for any nonconventional category (such as independent study and research), lack of consistency in dealing with multiple instruction assignments (laboratory and team teaching), and confusion over assignment of instructor workload to teaching or budget department. (Additonally, all faculty time was assigned to instruction). Considerable effort was devoted to writing processing programs to yield the ICLM and other derived data in the format required by RRPM.

Budget data provided the only basis for generating "for example" estimation equations and salary scales. These data were really too soft for modeling purposes because Stony Brook as a young institution behaves opportunistically with certain "wash effects" understood but not necessarily recorded exactly in the disaggregated form required.

Expenditure reports had similar and additional difficulties. Another difficulty was the lack of budget allocation of personnel within a department to specific functions (e.g., instruction, research, public service and administration).

By-and-large lack of internal consistency of data within and between the two data sources of Schedule of Classes and Budget proved annoying and will require continuing attention.

Parenthetically, a fourth data source should be formalized which should stem the institution's Master Plan. This would indicate desired relations among programs and resources, and yield estimation equations which are not merely a reflection of the past.

2.3 Validation of Model

Validation consists in adjusting the calculational structure, parameter values and degrees of disaggregation of variables such that model behavior is close enough to behavior of the institution to be useful. Stony Brook first aggregated all regular instruction into seven discipline divisions and sought to have calculated faculty output equal the budgeted value for a base year. At the campus level this checked, but not for individual divisions. This was due to a number of factors (a) the actual faculty appointments at divisional level not depending on student workload alone, and (b) the inherent differences between Schedule of Classes and Budget data bases. Ancillary personnel and support costs checked because the estimation equations fit the budget data well for the base year. This input/output procedure should be followed for each of the other variables of interest (e.g. dollars, space), noting carefully the effects of cross-coupled (or joint product) variables.

Having validated RRPM calculations for one simulation period it is next necessary to validate the links connecting simulation periods. In general, (though not necessarily), this produces projections over time, and so the check could be that of comparing outputs for years following an early base year with actual historical values. The only links connecting simulation periods in RRPM are salary inflation factor and end-of-year user-made modifications based on calculations from the preceding simulation. For small programming changes the inflation factor operation can be applied to other parameters such as class size and faculty load and thereby provide more flexibility in fitting model to actuality.

Stony Brook was fully engaged in developing its data base for seven discipline divisions for the years 1969-70 and 1970-71 and these problems took precedence over thorough validation. It is suspected that complete validation will not be easy and may require different variables subject to validation. At the very heart of model validation lies a question of its meaning for a growing institution, such as Stony Brook, for which patterns in the historical data are difficult to discern and for which future patterns should reflect plans. Validation may, therefore, assume the role of checking the technical operational features of RRPM.

2.4 Operational Modes

There are four useful ways in which the institutional data base and its RRPM processor should or may be run to present information to a decision maker as basis for his judgments concerning one institutional program in comparison with another:

(a) Selection of pertinent data. At present the report module flexibility is restricted to calling the same basic format for more subprograms or disciplines. It should permit looking at only selected items of both input and output data and of formatting them flexibly.

(b) Calculation of derived data. All types of calculations are fixed in the program at present, but with reasonable alternations some user flexibility could be obtained. In particular, subtracting certain categories out of support cost or taking the ratio of support cost per faculty, etc., would permit the user to look at different facets of an overall situation.

(c) Experimentation consists in establishing a set of different dynamic equilibrium conditions of resource requirements for various mixes of inputs and constraints. This capability is particularly helpful in determining an acceptable base year configuration (loads, section sizes, salaries, etc.,) which can then be projected over time.

Fortunately, RRPM presently can support this mode by "disconnecting" the links between simulation periods (only salary inflation at present). Stony Brook portrayed on the same page the budget results of nine experiments on the base year 1969 and also combinations of experiment and simulation (such as three versions of a three year projection).

(d) Simulation permits sectioning and linking together various stages of the university resource system such that outputs of one influence inputs to the next. This influence can be pre-programmed (e.g., salary inflation over time) or the result of user changes in parameters after use review (e.g., of faculty increase load). Currently RRPM is chiefly calculational but it could be sophisticated to include matching requirements against inventories and non-linear hiring or construction policies. Then also it could incorporate enrollment dependence on adequate faculty and buildings (a real Stony Brook situation). A version of the simulation which is gaining favor emphasizes posing problems and pitting one strategy of solution against another.

To sum up, RRPM offers at least a minimal capability in each of the four operational modes. It does lack flexibility but incorporates some growth possibilities.

Five separate stages comprise the running of RRPM, which can be operated independently or awkwardly coupled together via computer JCL (Job Control Language). Fortunately, successive simulation periods can also be coupled together for single pass running of a comprehensive problem. These stages are:

(a) preparation of input tape

(b) running of RP - Instruction

(c) running of RQ - other functions

(d) sorting the output data of RP, RQ or both

(e) running of RR - Reports

A complete run costs about $80 and the heavy computer requirements in core and tapes are such that running takes lowest priority at night. Therefore, it would be helpful to run only portions of the program for more restricted uses. Some of these are possible but Stony Brook did not have time to try them.

Stony Brook did explore use of its typewriter terminal at the start of the Pilot Test period, working cheifly with the Regression Module (AM) with fair success (later discarded). Stony Brook has operated its own resource calculators (workload, faculty and space) from the terminal, but the RRPM programs are too big and additionally the COBOL language of the Reports Module (RR) is not supported on its terminal.

When RRPM becomes modularized (and is entirely in FORTRAN) the terminal will be very useful for scanning and changing files, producing brief reports, and performing simple calculations and experiments. Also as an RJE (Remote Job Entry) station, the terminal would make overall use of RRPM more convenient.

2.5 Cost-Effectiveness of Data Capture, Processing and Use.

Stony Brook's special task was to examine critically the role and the associated cost of RRPM parameters and variables. A large effort was devoted to examining the relative influence of model input on output, deriving a relative importance of various data elements and the corresponding cost in obtaining RRPM outputs. But this proved meaningless because once RRPM was operating "any" type and quantity of data could be processed at the same cost.

Inasmuch as data exists to aid the decision-maker, one must consider the total data source/decision system to determine the most cost-effective trade-offs among original data type, error and timeliness, and final quality of decision. In this view, RRPM is simply part of data processing and does not enter significantly into the cost-effectiveness analysis. Instead, one focuses principally on the decision arena of the particular institution, on the role played by data, and on the incremental cost of increasing the quality of current data or of providing different data (in type or level of aggregation). Results of this special task analysis may therefore not be generally applicable, as the following illustration may indicate.

At Stony Brook, certain major resource decisions must be made early in the term when course selections and assignments are still fluid. Additionally, furnishing accurate timely data for students and faculty appears to be difficult. Although to "harden up" these data is very costly in time and effort, it may be "worthwhile". On the other hand, if the same type of decisions are made at the same time each term, the quality of the data (if above a specified minimum) may not be critical. If the derived data needed are different than those produced by the "RRPM processor" (such as student/faculty ratio) a processor developmental cost would be incurred. In all situations the required data may be assembled quickly via a meeting of experienced persons at greatly reduced cost. Thus each situation requires its own careful analysis. Section 1.4 of this Summary Report has mentioned other examples requiring further attention.

It was the intimate working with RRPM which brought much of this into focus, and now prompts Stony Brook to organize data in terms of the character of the decision to be made.

Directly Associated Personnel (Feb. 70 - Aug. 71)

Mr. G. Osborn	SUNY Central, Ass't Vice Chancellor for Management
Dr. J. S. Toll	President, Stony Brook
Dr. T. A. Pond	Executive Vice President
Dr. W. E. Moran	Assistant Executive Vice President
Dr. D. L. Trautman	Acting Director, Long Range Planning
Dr. J. L. Bess	Director, Planning Studies
Mr. B. G. Wacholder	Senior Analyst/Computer Specialist
Dr. D. Sun	Senior Analyst/Programmer
Mr. B. Ramnath	Programmer/Analyst
Mrs. M. Ulrich	Programmer/Analyst

Other Active Stony Brook Task Force Members (Feb. - June 71)

Dr. C. Hoffman	Assistant Academic Vice President
Dr. D. Dickson	Assistant to the President
Dr. E. Lambe	Director, Instructional Resources Center
Dr. E. James	Professor of Economics
Mr. D. Tilley	Director of Admissions
Dr. D. Dicker	Executive Officer, College of Engineering
Mr. R. Glasheen	Administrative Ass't to the Dean of Engineering
Mr. R. Franciotti	Director, Computing Center
Mr. F. Abeles	Manager, Administration Data Systems
Mr. J. Diana	Vice President for Finance and Management
Mr. D. Butera	Director of Management Information System

RRPM Staff Personnel of NCHEMS at WICHE

Dr. W. W. Gulko	Director, Development & Applications Program
Mr. J. S. Martin	Staff Associate
Mr. C. R. Thomas	Program Associate for Information Systems

RRPM Pilot Test Participating Institutions

Mr. T. E. Davis	University of Utah
Dr. D. Lawson	Humboldt State College
Mr. H. Fischer	Washington State University
Mr. A. Harris	UCLA
Dr. K. M. Hussain	New Mexico Jr. College
Mr. R. J. Low	Portland State University
Mr. M. Roberts	Stanford University
Dr. D. L. Trautman	SUNY at Stony Brook, NY

VII

SUMMARY OF RRPM IMPLEMENTATION AT THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

A. Harris, W. Smith

EXECUTIVE'S STATEMENT REGARDING POTENTIAL OF THE MODEL

RRPM is a valuable tool for a campus in determining the long-range resource needs to carry out a specific program defined in an Academic Plan (assuming, of course, the availability of workload standards and other standards used for the determination of resource needs). In the case of resource allocation, however, RRPM can only be a useful campus planning tool where there is consistency year after year in the receipt of resources, in our case from the State of California. Unfortunately, for the past five years all funding formulas have been disregarded and for the last two years in particular we have had substantial reductions in faculty and support dollars, despite growing workload. Needless to say, given our tenure rules faculty reductions had to be made where they could be accomplished (where unfilled or temporarily filled provisions existed) rather than on the basis of workload criteria which could have flowed from an adaptation of RRPM.

It is essential that the results of RRPM be framed in terms of the organizational structure of a campus if decision making is to benefit from its existence. Where institutional standards are applied routinely in the allocation of resources, RRPM can be an invaluable tool.

Without fully understanding differences in programs among a variety of educational institutions, RRPM will not serve to facilitate interinstitutional information exchange.

DATA ACQUISITION PROBLEMS

The information was organized to drive our own simulation model and thus our data acquisitions problems should have been minimal. The biggest job was structuring the input according to the WICHE Program Classification Structure. Other problems were as follows:

1. Faculty contact hours were recorded by level of faculty, not by level of course. We were reduced to using average for all faculty of a discipline.

2. Since we used 5 types of instruction: 1) lectures, 2) seminars, and 3) quiz-discussion had to be averaged together for "first type." This creates a meaningless average. "Second type" corresponded to our lab courses; "third type" was tutorial.

3. The ICLM did not accurately reflect the workload imposed by the medical students, (see validity testing). In general the health sciences budget is arrived at in a quite different manner than the general campus.

4. In general, administrators with academic titles had to be individually tabulated along with partial FTE and added stipends. This was time consuming. Salaries for academic research staff was assumed to be the same as in instruction. This is not necessarily the case since at UCLA they are not the same persons. The average of non-academic salaries over all of organized research is not typical of some disciplines.

5. Data are frequently gathered by unit and then have to be entered in the file by type of information. One can't do it both ways, but when one wants to revise data for one discipline it requires a lot of scrambling.

6. We were pleased that most space information was available with minimum crossover. Classroom utilization is campus-wide and whenever there is a campus-wide (Registrar's) pool you can't get utilization by discipline. Cost of construction data is of no importance to us.

7. The historical file proved quickly that very few regressions would be applicable. No significant growth is anticipated in terms of number of students, but this is the basic mechanism that drives the model. In some changing departments (growing or shrinking) non-academic staff could be associated with academic staff. In others and in most administrative units, constant projections were made. All regression coefficients were hand entered as changes to the dummy file from a console in about six hours. The historical file of 7 years' data was for instructional departments only, all non-instruction data was hand gathered for three years. The latter were mostly constant over these years so the projections were usually constants or simple ratios.

8. Projected number of students by discipline changed daily. We had to keep track of revised categories and put students back in categories expected by ICLM, (rather than guess new entries in ICLM). Similar adjustments in administrative account numbers were required.

9. Certain data do not fit the format of RRPM. Most of these are unique to our institution, but other institutions probably have their own non-conforming data. For UCLA this included:

   a) Data for units where a substantial amount of the budget is recharged to other units. The recharges were originally handled as negative supplies and expense. This would be fine if the report generator accepted negative numbers. In the present case, some FTE were reduced to force positive numbers. Since the personnel are actually there, this was undesirable.

   b) We have budgeted "provisions for allocation." This was simply ignored in RRPM, and next year's budget has eliminated this item.

   c) The summer session is supposed to be self-supporting. We do not have data for modeling it in detail so it was ignored.

d) Our budget imposes a mandatory budgetary savings of a fixed percent. This was ignored as it is not necessarily uniformly distributed and varies with the number of new positions budgeted (or withdrawn). It has been as high as two and one half million dollars which usually came from "academic salaries."

TECHNICAL DIFFICULTIES IN OPERATING OR IMPLEMENTING THE MODEL

The major difficulties were the initial implementation with control card problems and the continued updating of the programs. We used an IBM 360/91 under an OS system.

The initial implementation occurred when disk space was not available except on system files, so the temporary file structure made it desirable to run both parts of PM (RP and RQ) as a two-step job. We never ran it otherwise (although it would be easy with our own disk pack now). In general when changes in data were required it affected the input of RP so both parts would have to be run. We did compile and create load modules separately. Changes in RQ were made where only it would have required running. Appropriate changes in the output file would have to be made.

The output was written on a single file which required us to use the DISPosition = MOD parameter. Chuck Thomas and Jim Martin were very helpful in implementing the initial test.

The file INPOL was split four ways. The first card was read from the card reader (change in a program command); the next block was a separate file for the ICLM; the next part (in the same declaration) was the rest of the data for INPOL used in the first part (RP). A separate file INPOL2 was used for input of the second part (RQ).

Since no one on our staff and few at our Computing Network are familiar with COBOL, the report generator was a problem. The WICHE staff got it going, seeing that the internal declaration matched the Job Control Language, etc. It was also difficult to tell if the corrections we were making made sense. More than one man-week was lost because a correction that was to be voided had not been. This error was found only by matching every statement in the program as compiled with the original listing.

In general no compilations were done until programs were to be run (for a deadline). Thus we had most corrections and corrected corrections in hand and did not spin our wheels finding errors others had already found. (This was not true the first time around with the program supplied from outside WICHE where we could only find errors by running WATFOR with 500K memory).

AN ESTIMATE OF THE COST OF MODEL OPERATION

An estimate of costs of implementation and adoption of RRPM is $12,200 direct cost and $27,200 indirect costs. One might reasonably expect the miscellaneous costs, running/testing model and meetings/reports, to be half what we experienced (except for EAM costs). This would reduce direct costs by $3,900 to $8,300.

The estimate of our indirect costs of $27,200 may be low for what we actually did. The development of a historical file, especially one with many levels of aggregation (see data acquisition) required the time of a programmer for 6 man-months with some quite expensive computer costs. (An experienced programmer could have done it for considerably less). The creation of a program to summarize expenditures and wages was also quite expensive because it summarized by unit and by each type of funding source (a problem that caused extensive reruns of a long program with a great deal of data). The development of these programs was listed as using $7,000 worth of computer time with a total direct and indirect computer usage of $10,500. The total office usage for the last year was more than $25,000 which included some UCLA developmental costs on our own simulation model and student flow model and repetitive runs of the programs.

Recent experience (with computer rates 11/15 what they were previously) for runs with two years, live data, all calculations, is as follows:

Step	Cost	In	Out	Core
Compile & Load RP	$10.46	(13:15)	(13.20)[1]	234K
Compile & Load RQ	19.07	(12:32)	(13:18)[2]	234K
Compile & Load RR	6.50	(16:08)	(16:22)	144K
Execute RM (RP & RQ)	86.43	14:47	15:35	174K
Execute Sort	3.28	15:58	16:08	246K
Execute Report Generator				
with Both Overrides	11.68	16:14	16:30	74K
with Discipline Overrides	18.90	16:33	17:22	74K
with No Overrides (Programs 1 & 2)	63.78	16:44	20:17	74K

[1]With priority. [2]Followed by execution steps as convenient.

Operation was from the console for all execution. That is, programs were submitted from the console, generated as batch jobs, output was available for viewing on the console at the time given as "out." The last run of the Report Generator with no overrides produces more than 100 pages of output so is queued for the printer and is low priority output (no viewing from console). Compile and load steps were done with card deck submission. The programs could be stored on disk and changed, compiled and loaded from the console. Further discussion of this aspect is contained in the section on "Remote Terminal Operation and Real Time Terminal Possibilities."

Additional charges would apply if one keeps the input data sets on disk (232 track @ 40¢/track-month = $92.80/month storage) where it can be modified directly from the console (visual verification). Hopefully we will have this capacity soon for our private disk pack ($12.50 per month rental).

For repeated use of RRPM, the maximum values of the parameters could be reduced to save money and time. More important, the direct access files created in RP could be created in core which would save us much of our Input/Output charges.

With priority we should be able to complete the execution of PM, sort, and simple report in less than an hour. This would include time to look at PM output before proceeding with the sort and report generation.

AN ANALYST'S EVALUATION OF RRPM'S PRESENT APPLICABILITY

UCLA thinks a simulation model is extremely valuable; that is why we have used this approach often in the past.

(a) Types of planning to which the system is applicable

The most useful part has been the projection of workload upon departments (or divisions) as the student mix changes. The use of the Induced Course Load Matrix has been extremely useful. Even though it may vary some from period to period, it gives us a better handle on workload than we've been able to project otherwise.

This estimate of workload then enables one to project faculty needs, and hopefully influence where cuts can be made (although it has usually been a matter of locating open or temporary positions). The system works better for an expanding institution! Our office uses the workload measures (student credit hours, by major and service load) as a primary tool in making recommendations on changes in faculty allocations. The corresponding changes are built into the ensuing budget.

At present the budget analyst aids the building of RRPM more than vice-versa. Where the budget officer uses certain relations (particularly in non-instructional units), we would like to build these relations into RRPM. Eventually, this would replace some of his hand calculations. The last budget preparation requested much information in WICHE-RRPM format with corresponding workload measures so that some of our data was extremely useful.

We have also been able to assist the facility planners. The projected number of students and the projected workload are used with university standards to project the space needs and the actual reports required to be submitted to University-wide offices are produced by our own program that uses the projected full-time equivalent students by discipline. The facilities planners are keenly aware of our projections as they look for justification for the one building we hope to get funded. The RRPM projection of cost of buildings is of no interest to them under present circumstances.

(b) Functionaries who are concerned with RRPM

As mentioned above, the budget analyst (who prepares the budget drafts) and the chief facilities officer are directly concerned with the output of the model. These two officers report to the Director of Planning, a cabinet level officer who serves as direct staff to the Chancellor (see Appendix J for organization chart of UCLA Administration and of UCLA Planning Office).

The recommendations of the Planning Office regarding staffing and facilities go to The Vice Chancellor and the Chancellor who makes the allocations to the deans. The divisional deans (e.g., of Physical Sciences) have authority to change allocations within their division so they are informed as to the recommendations with supporting reasons. The Vice Chancellor and the Chancellor are quite aware of RRPM. The deans have not been involved. Occasionally a dean or department chairman will become aware of RRPM and the corresponding data when he asks us for data (e.g., to justify requests for relief from excess load).

Of special interest is the use of the Induced Course Load Matrix to provide departmental workload estimates to the Planning Section of the Academic Senate Budget Committee. The Assistant to the Director of Planning attends its meetings and provides extremely valuable lines of communication. They are aware of simulation models and have bought the concept of using an ICLM to project workload.

(c) Subsequent analysis of model output and input

As indicated above most of the interest in RRPM centers on the Instruction and Research Departments with their corresponding workload (by major load and service loads, by level). We need departmental data so that the RRPM Model needs 60 units (not counting Health Science departments) to be useful for departmental planning. Also, the PCS would be discarded for non-instructional units as the present accounting structure is what administrators understand. We used a crossover to get accounts into WICHE sub-programs, but to be understood, the output would have to be put back into the UCLA structure. This is no great problem if one simply ignores PCS, but is willing to use their number of accounts and level of aggregation.

I believe that the analysis of the input may be even more valuable than the analysis of the output. The decisions as to what we want to drive the system, what relations we want to exist, and the analysis of the data gathered to make the model run can lead to a better understanding of the system and, therefore, lead to changes that have little to do with analyzing the numbers that come out. Some examples are given:

We can analyze the support dollars per faculty member by department. Can we isolate a constant (fixed support) for department plus a variable cost? (Certain departments have argued successfully that when we withdraw FTE we can not withdraw proportional support because there is a fixed constant part of support needed). Should support be approximately the same for all departments in a given discipline? Can we justify the differences? We can analyze class size. (If we don't someone else will). Can we justify certain small classes? Should we try to maintain certain averages? Should there be differences we observe?

Similar analyses of faculty workload, proportion of tenured faculty, etc., are abundant.

VALIDITY TESTING

Using data that was as current as possible as input to the RRPM, the validation was done in terms of projecting the budgeted items for 1970-71 which corresponded to most input parameters and projections of 1971-72. The allocations for the 1971-72 budget were distributed two weeks ago so that not all details have been checked. The projections of the budget at the sub-program level as printed out for two years and the actual allocations were output from a second revision of inputs. A third revision would make certain discipline projections more accurate, but the total for 1970-71 could be made more accurate only by extensive detailed analysis. We shall point out changes that occurred in one revision and why the discrepancies in 1971-72 occurred:

The first run showed us that two sub-programs had no data because the subroutines in the prediction module had not been activated. The "return" cards in these cases had to be deactivated. The subprograms were Ancillary Support and Independent Operations.

Also, Financial Aid (5.4) was off by 30 percent because the regression coefficients had the wrong index. Instruction was off by 50 percent. We could not get the report generator to work at the discipline level so all we had to go by was the total cost by discipline printed out at the end of RP. This indicated that the health sciences were three times what they should be, but no details were present to give us clues. When the discipline print-out was available, and the 1971-72 budget was on hand we were able to find many more errors.

In order to project budgeted staff the workload figures are obtained by dividing the contact hours by the number of budgeted positions. This may deflate the workload if professors are not teaching that quarter or if the position is not filled. Since the workload data was based on fall quarter with four quarter budgeted staff and projections were for three quarter staff, we adjusted the staff figures to remove the fourth quarter staff. In reality the "fourth quarter" staff had been used to bolster all quarters and very little staff were taking off fall quarter so the workload was about correct and should not have been adjusted. Removing staff in the computation increases the apparent workload and means you think you can accomplish more than you actually can with the result that most divisions projected 10 to 20 percent less faculty than actual. An adjustment was made and it will be interesting to see if our "adjusted contact hours" agree with the tabulation now in progress.

The file for Health Sciences was apparently so incomplete as to be worthless. About one-third of the workload appeared to be represented. Since Health Sciences are budgeted entirely differently, this had not been of concern before. This is a case where the workload measures come from a very different source than that of the Induced Course Load Matrix so that the student credit hours generating the two files were not at all consistent. Some of this could happen simply by using information from two different years so, if possible, it is recommended that workload data and ICLM be for the same period. At present we use fall workload data and fall ICLM. When we get year-round workload measures, we will use year-average ICLM and year-average projected headcount.

Social Sciences had projected 60 percent more faculty than actual. This was accompanied by a lack of any faculty projected in Communication or Public Service. The ICLM was wrong. Journalism is in our Division of Social Sciences and was left there in the ICLM; but regressions, staff, and budget workload all assumed it was "Communication." The School of Social Welfare was simply coded wrong so that its entries were included in the ICLM with Social Sciences instead of Public Service. Two quick changes of index numbers (from the console) were all that was required before generating a new ICLM ($45). The confusion did mean that the workload in terms of contact hours per faculty in Social Sciences could not be adjusted as neatly as we would like. If we were to adjust it again it would increase the error in total Instruction from 3 to 4 percent in 1970-71 and decrease the error in 1971-72 from -6.1 to -5.1 percent.

The budget for 1971-72 reduced our faculty by 90. For a faculty of 1,500, that is a reduction of 6 percent. The percent error of our projections in Instruction for 1971-72 was 6.1 percent which seems very realistic. Individual research (committee grants) has also reduced about the same amount.

The Instructional Program is our primary interest as the other programs are more likely to be constant or controllable at an institution that is not adding students.

Other errors we found included a problem with libraries. Librarians are classified as academic employees and get left out because there was no slot for such types. They became "administrators" (all 144 of them) with academic appointments. Library "supplies and expense" was computed with a linear equation that was just wrong. In adjusting personnel figures in Audio/Visual Sciences to counteract recharges, an error was made in the adjustment. These were quantities that contributed from 17 to 23 percent errors in their sub-programs.

Financial Aid was still off by 9 percent because level 7 students were not counted. The formula was adjusted and the program recompiled.

The budget analyst looked at financial operations where the actual appeared to decrease 13 percent next year and found that we had left out the new account for financial management. Any crossover has to be watched when accounts are created or renumbered!

The biggest percentage error left in base year projections is 3.3 percent in Organized Research (2.1). Personnel seems to be accurate. It is difficult to compare budgets because of the use of average salaries whereas some disciplines are 30 percent below average.

Projections for 1971-72 did not take into consideration the following items:

1. A withdrawal of 6 percent faculty with no decrease in the number of students.

2. A corresponding decrease in State funded individual research grants.

3. A large drop in University Extension workload (3.2 and 3.3)

4. Associated drop in Museums and Galleries.

5. A 10 percent increase in Audio/Visual. Perhaps this is a trend we could build in.

6. We would hope to build in additional computer support but we estimated exactly no change and were right this year.

7. Ancillary Support was up 8 million dollars due to the increased size of our hospital. This big a step is a one-time operation but we should expect health sciences to be an area of increasing budgets.

8. As student fees go up, the students are demanding more say as to how fees are spent for student support. They recommended consolidation and decreased budget for counseling and career guidance. Financial Aid is up some to offset increased fees.

9. The Institutional Support total could probably be estimated with one "inflation like" factor. Sub-programs vary in ways that have not been analyzed. Faculty benefits (6.6) did have a sizable increase that was announced.

This explains most of the discrepancies in the 1971-72 projections.

"REMOTE TERMINAL OPERATION"

UCLA has been using terminal operation of RRPM for all runs done this year (1971). Our latest experience (time, cost, region) is given in the section on "An Estimate of the Cost of Model Operation." Further details on terminal operation will be given followed by a discussion of real time alternatives.

The present UCLA terminal operation is from a CCI (Computer Communication Inc.) terminal with a UCLA processor known as URSA which communicates (up to at least 40 terminals simultaneously) with an IBM 360/91 with OS system which uses MVT (variable number of tasks) up to 10 batch type jobs sharing the CPU (Central processing unit). The system has interactive APL and "Quickrun" that processes small jobs from a card reader while you wait. It has 4 million bytes of core, some 16 disk packs that can be used by users that are always on-line so their contents can be viewed and changed instantaneously from the console. Private disk packs can be mounted on request (e.g., called by a program) but at present their contents can only be changed by a program.

By console operation of RRPM we mean that we have load modules of the compiled programs which can be called from the console, submitted in queues as batch jobs processed under MVT and the output returned to the console for viewing and printing if desired. The printing is done at the computing facility although a printer could be attached to the console for another $8,000. (The console costs $8,000). The data sets are on computing disk packs where they can be changed at any time from the console. The documentation of such a system is the same as that of the RRPM with no more modification than would be required in any job control language as you change from one installation to another, along with the documentation of the processor (call submit and give the name of the data set which calls the job; transfer to "Master Statistics" to monitor the processing of the job; transfer to "Output" to scan the pages as they would appear on printed output; transfer to "Modify" to change any elements of a data file). For a given system an index of input would be handy that gives the exact location of each data element. Otherwise one has to guess where the data set with NN=32 is and skip through until one finds it starts with record 3 of block 432 (out of 1375). Such an index should not take more than one man-day to write.

If one requests priority the prediction module can be run and output viewed from the console in less than 10 minutes (7 1/2 on one occasion) for 2 year projections. If the report from this is all you need to interact (or if one can print out all that one needs at this point) then I would say you have Real Time Operation in at least one sense. It would be prohibitively expensive on our system ($86) unless one were able to subsequently use the detailed output. It needs only a knowledgeable programmer to change the input. As mentioned under cost details, by reducing various parameters and by using core instead of direct access temporary files, we could speed the time and reduce the cost considerably. (Our system penalized heavy input/output).

Aside from the costs of execution, there are storage costs on our system. We are charged 40¢ per track-month of data sets stored on system disk packs. Requirements (for maximum parameters) are:

	Tracks		Tracks
RP Fortran	23	Load Module	17
RQ Fortran	40	Load Module	26
RR Cobol	31	Load Module	10
INREG			105
ICLM			109
INPOL1 (Rest of INPOL Used in RP)			12
INPOL2 (INPOL for RQ)			6
PMOUTPUT			95
Calling programs 2 tracks each; sort 1 track			5

We keep only data files and calling programs on system packs for a total of 332 tracks or $132.80 per month. Hopefully this can be reduced to zero soon. (We can move them to our own file for a dollar or so each and move it back when needed).

VIII

SUMMARY OF RRPM IMPLEMENTATION

AT THE UNIVERSITY OF UTAH

B. M. Cohn

Institutional Characteristics

President James C. Fletcher joined the University of Utah and in 1964 initiated a number of activities which have both facilitated the collection of data and readied the institution for the use of computer tools in planning and decision-making. The current President, Dr. Alfred C. Emery, served as provost under Dr. Fletcher and is continuing a strong committment to planning. The following have been in progress and have helped in developing RRPM:

- Summaries of enrollment statistics
- Projections of enrollment
- Computer registration and scheduling of students
- Surveys of faculty effort
- Instructional costs by academic department and grade level
- Departmental 10 year plans
- University financial plan
- Pilot application of comprehensive planning in selected departments

The data is developed on the University's IBM 360-40 and the RRPM programs are operated on the University's UNIVAC 1108.

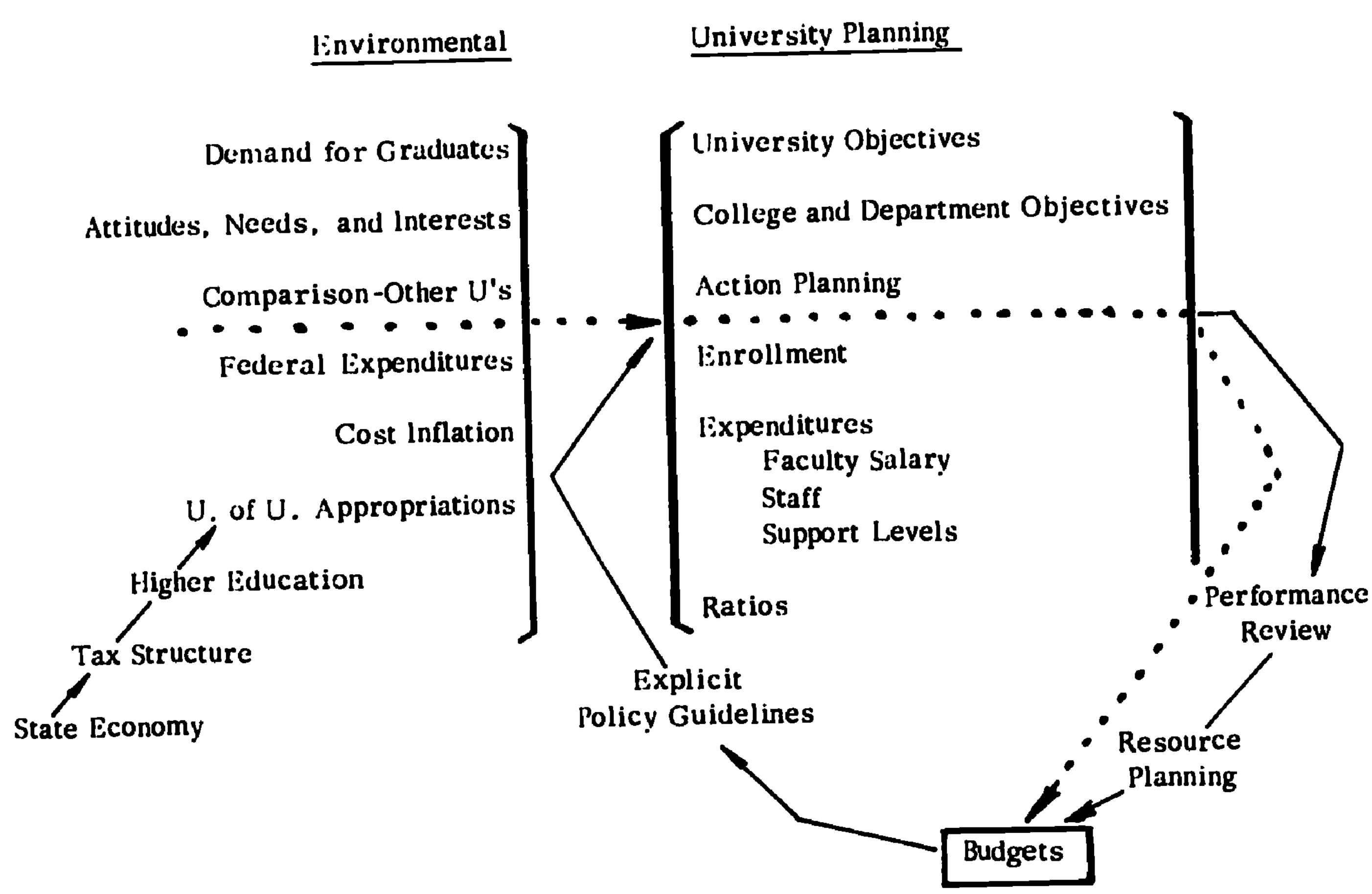
The Planning Process

It is important to recognize that as a computer tool, RRPM can be a useful part of the planning process. RRPM and other computer mechanisms are not a substitute for thoughtful planning. Computer programs are tools that can facilitate a logical management process; but the tools are not gimmicks which automatically produce sound plans. This section presents the way that planning is designed at the University of Utah and the way that computer-facilitated numerical analysis fits into the total effort.

On the chart below, planning topics are grouped in two categories: environmental conditions, and university planning. Environmental conditions are those that are external to the University that influence, or should influence, our actions. The first environmental factor listed is comparison with other universities, their teaching approaches, success or lack of success, resources employed, etc. The attitudes of the public and our own students and faculty are important in defining objectives and priorities. Manpower needs in the nation and state will determine the success of our graduates in finding employment in their chosen fields. The next series of factors are numerical trends which directly influence the amount of resources available to a university: federal expenditure trends, cost inflation, and appropriations within the state.

University planning lists subjects which should be interrelated in practice. The University's objectives should be articulated in a way to provide operational guidelines for colleges, departments, and individuals in formulating their own objectives and to permit a framework for constantly testing both the University's objectives and those of the individual organizational units. Special studies and action programs are undertaken to address the objectives. Finally, numerical factors are listed including enrollment, expenditures, analytical ratios, etc.

THE PLANNING PROCESS



In both lists, dotted lines are indicated which separate the numerical information which is the focus of RRPM and is frequently all that is done in planning. Out of the numerical analysis that does go on, a budget is developed. The budget communicates a great deal to a dean or a department chairman about his programs and status in the University. However, it is not always the intended message that is heard. The process would be imporved considerably if full advantage is taken of the opportunity afforded by the budget to communicate explicit policy guidelines.

The final topic listed is one that has not made much headway in higher education: performance review, and its potential role in resource allocation. As a minimum, performance review can be a qualitative comparison of achievements against prior objectives and goals. A further step is getting more attention than it has, evaluation of the results of educational efforts, and the practices and conditions which are most conducive to achieve a high amount of learning.

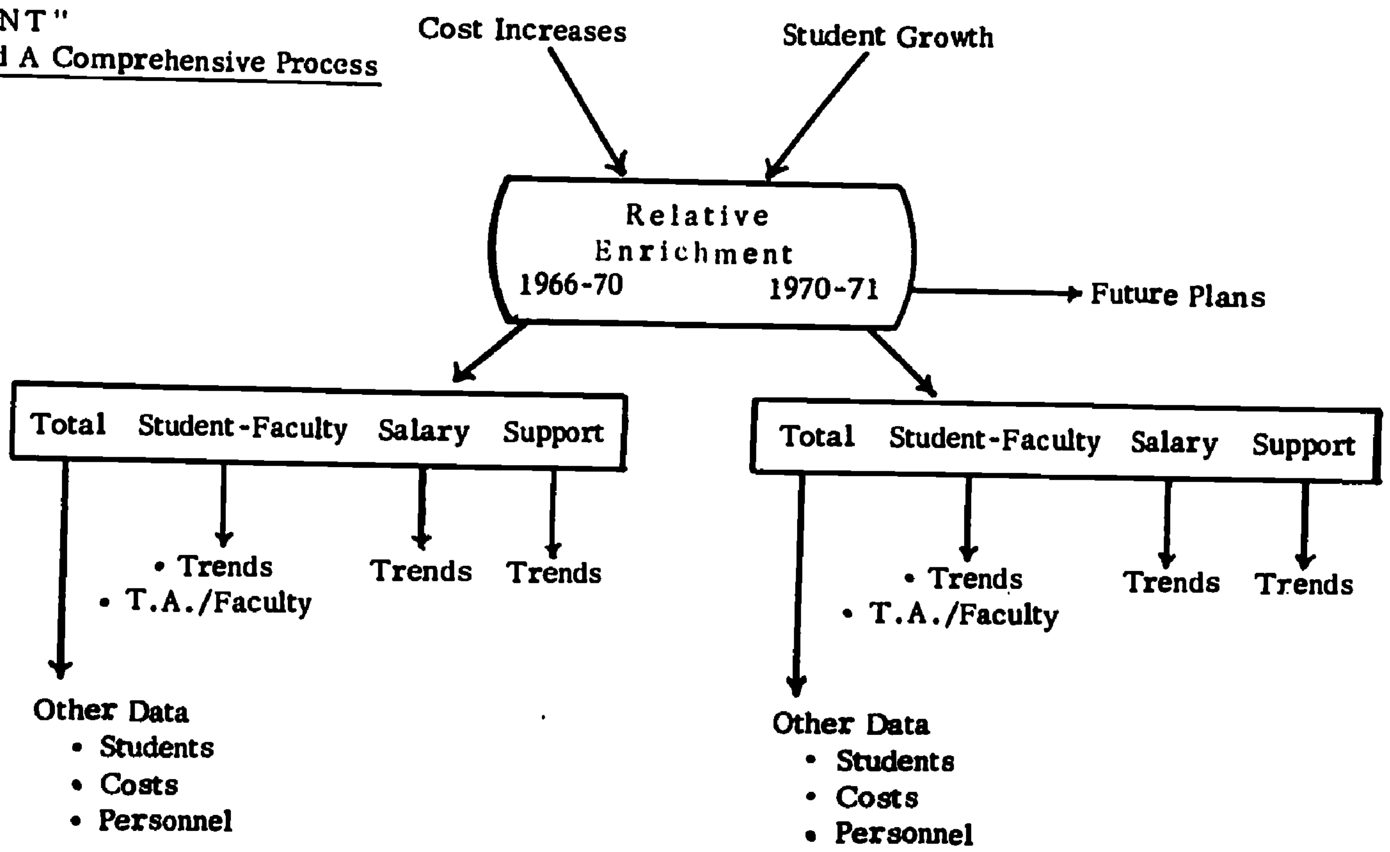
At the University of Utah, we believe that to be most effective in the long run we must make some progress on all of these topics and involve a broad spectrum of faculty, students, and administration; and the Long Range Planning Office is operating on four types of activity. First, we are working with the administration to frame a position on objectives and priorities to be used for general discussion. Second, we are working with the administration to frame a position on objectives and priorities to be used for general discussion. Second, we are working on a system for bringing numerical data to bear on decisions. One task is participation in WICHE RRPM-1 pilot. Third, various portions of the process are being piloted in different organizational units, and in one department the Long Range Planning Office is working closely to assist in developing a comprehensive plan. Fourth, the Provost has formed ad hoc action groups to address priority concerns and Long Range Planning is available to provide assistance to the action groups.

"Enrichment," One Step Toward A Comprehensive Process

As part of Utah's RRPM effort, we developed a way of analyzing instructional costs that is referred to as enrichment. This measure beings together cost increases and student growth over time. Enrichment is the annual rate of change in expenditures per student for a given time period. This measure can be used as a point of departure to raise questions about how resources have been used in the past; what departments have received the greatest and least increases in funds relative to their growth; how the funds have been allocated within the department; what level of instruction has been supported the most heavily, etc.

It should be recognized that the level of expenditures is also important, as well as the changes in amounts. Enrichment is only a rate of change in a unit amount which can be used as a road map to analysis.

"ENRICHMENT"
One Step Toward A Comprehensive Process



Organizing for RRPM

The pilot testing of RRPM at the University of Utah is a cooperative effort involving the direct effort of the following departments:

Long Range Planning
Budget Office
Controller
Institutional Studies
Data Processing
Space Analysis

In addition, several executives have guided design of information needs, reviewed preliminary data, and struggled to apply the results to management decisions:

President
Provost
Executive Vice President
Academic Vice President
Financial Vice President

The cooperative effort was led by the Long Range Planning Office.

From the beginning, effort was concentrated on defining and testing data as it would be used for decision making and one college was used as a pilot test. The original data definition was unacceptable to management. Management rejected the use of two amounts as guides for resource planning: 1) "status quo" as a percentage of University average expenditures per student and 2) the University average itself.

The management review team suggested that they could work with enriching a department by x percent. Thus, the frame of reference was developed that is illustrated in this report. It should be noted that "real" enrichment of resources is achieved only when the annual rate of enrichment is greater than for cost inflation. Two other major observations were made by the management review team: 1) the need for complete data on each department covering all expenditures and 2) the need for data on space requirements.

The early efforts involved about 1 to 1 1/2 FTE analysts, primarily in the Long Range Planning Office. Once the output requirements were clarified, the cooperation of the staff departments were intensified and major data collection undertaken. At the peak, under pressure to meet commitments to the academic calendar, as many as 6 analysts, programmers, and planners were involved. The average for the project was 1 1/2 - FTE persons.

There are a number of lessons from this effort that should be passed along to other who wish to gear-up for use of RRPM or any other mechanized analytical tool. These are discussed in the remaining paragraphs of this section.

The attention to management application and format is valuable and universities are advised to devote early attention to this kind of definition. If Utah were to begin again, we would do even more applications testing. It would have been useful to test the total resource framework (all PCS programs) including research, service, and space on a pilot area before attempting to apply the data to the entire University.

The existence of several data applications at the University of Utah may put the existing data base well ahead of many universities. However, each application proved to be designed as a separate "module" and considerable effort was required to match data files that are not matched in normal practice. We found that in some ways our problem was too much data, and we had several "data bases" that needed to be merged. We found elements with obsolete codes; there were elements that had no codes and had to be "cleaned-up"; files included codes that were not anticipated, etc. The most difficult area to work with is payroll files. The ready accessibility of good payroll data will be valuable to anyone seeking to apply RRPM.

Even with a fairly good data base, a one-year time frame is tight to design and program effective applications and also gather data. The application design work must be done, or the effort will not be fully effective. If we were beginning again, we would urge a longer time span, say two years, for implementation. However, it is conceivable that a university starting now might do a satisfactory job in one year if it uses the pilot experience to carefully design the university's own institutional-planning data. At the University of Utah we have put ourselves under extreme time pressure because we delayed data collection until we were satisfied we knew how data would be used. The current requirements to drive RRPM might provide a satisfactory data base for flexible application. In other words, by careful absorption of the pilot test experience, data collection and applications design could be carried out in parallel.

Spreading the implementation calendar would help progress in another way. At the University of Utah, as on other campuses, a number of committees and special project teams are attempting to bring about educational reform. It would hasten grass roots acceptance and understanding of planning to develop special data for the reform efforts and share with them what is already available. We have attempted to do as much of this participation and sharing as possible, but a longer time frame for RRPM first phase implementation would permit more time for work with university and departmental committees.

<u>What Else Have We Learned</u>

Enrollment planning is essential if the intended effect of budget decisions is to be realized. The differential rate of growth from year to year makes it extremely difficult to control resource priorities exclusively through the budget. Too often enrollment projections are ignored, and considered unimportant, or are mere numerical extrapolations of history. It is extremely important to reflect in meaningful projections an assessment of the job market for graduates and skill requirements for the jobs of the future; expert judgments should be sought from department chairmen, deans, and administration; and projected growth in each area to be used for planning should be established by negotiation. This same kind of data should be shared with students through an effective counciling mechanism so that students can make informed and mature decisions about their own academic choices. Finally, we need to gain a better understanding of how students are motivated, and what it is that changes student flow patterns.

Space data should be integrated with cost data because either is a resource that may become a constraint on growth.

Commitments for research have many long term aspects. University resources are channeled into matching funds, projects and people stay on after grants expire, etc. As funds become tighter, these commitments severely limit the room for discretion over resources. It is essential to pull all aspects of operations together so that the future impact of all commitments may be tested before new commitments are made.

Cost

An institution planning to start RRPM will want to know what amount of cost it can anticipate. A number of cautions are in order in interpreting the costs at the University of Utah. First, there was a deliberate attempt to hold cost to a reasonable level and maximize productivity. However, there are a number of factors which held RRPM costs lower than they would be otherwise: a large amount of data already existed in machine readable form; a consultant was hired independent of RRPM to develop space data, and the data required little modification; long range planning efforts were underway which were modified with minimum extra cost to simultaneously fulfill planning needs and RRPM data needs. Second, effort was made to use RRPM as the planning tool at the University of Utah. Tasks were merged in a way that makes it fuzzy to ascertain what costs are incurred for RRPM and what costs are incurred for other distinct efforts. The cost allocation presented on page 16, totaling $37,550, is an attempt to make a realistic separation of the direct costs.

IX

SUMMARY OF RRPM IMPLEMENTATION AT WASHINGTON STATE UNIVERSITY

H. C. Fischer, G. R. Kissler and J. D. Lawrence

PREFACE

The following is an overview of the activities performed by Washington State University as a pilot test institution for RRPM. The document has been designed for general distribution, particularly for institutions planning to implement RRPM. A complete report describing data collection methodologies, model validation techniques, problems encountered and other aspects of the overall task is available upon special request. This and the complete report also include similar descriptions of a sensitivity analysis technique which was developed and implemented as part of the overall pilot test exercise.

The total report consists of three documents:

1) RRPM implementation and evaluation.
2) RRPMSYM an analytic sensitivity analysis model.
3) RRPMSYM source program listing.

Each of the above is available upon special request from:

Office of Institutional Studies
6015 Design Discipline Building
Washington State University
Pullman, Washington 99163

A $5.00 charge will be made for each document to cover reproduction, handling and mailing costs.

Summary:

Experience to date at Washington State University indicates that the current state of modeling technology offers many immediate benefits and promises significantly greater future benefits to institutions of higher education. The collection and analysis of historical data required to construct or implement any meaningful model cannot avoid providing insights which otherwise would go completely unnoticed or at least unquantified. This was no exception with RRPM. Specific benefits derived from the implementation of RRPM at Washington State University are: 1) a more accurate and complete data base for future decision making, 2) an increased understanding of university cost and resource requirement relationships, 3) an increased understanding of modeling, and 4) a renewed vigor toward long range university planning.

Although RRPM was available and at least partially implementated during a major budget planning period, its use was almost entirely preempted by other techniques. Besides newness, lack of pretesting and other problems associated with new tools, several other problems existed. Specific obstacles were: 1) the incompatibility of HEGIS discipline division and program classification structures with existing university structures, 2) model input, output and update inconveniences, 3) the high cost of running the model, and 4) limited turnaround capabilities. Some of these obstacles will be diminished in magnitude by enchancements incorporated in the model to be released for general use, e.g., increased dimensions, reduced core requirements and a group data modification capability.

The most significant deterrent to actual use was adherence to the HEGIS discipline classifications as specified in the pilot test contract. Unexpected values and relationships were difficult to validate and explain due to the unfamiliar groupings of departments within a given HEGIS classification. At Washington State University, planning generally occurs either at the college level or the department level. The HEGIS classification structure satisfies neither of these conditions. For instance, segments of the College of Agriculture appear in the disciplines: agriculture, engineering, education, and biological sciences. Although this requirement was subsequently removed by WICHE, the induced course load matrix, expenditure crossover tables, and a majority of the model coefficients and parameters had already been calculated. Reconversion was impractical within the allotted time frame.

The following statements summarize the evaluation of the pilot test study at Washington State University.

The exercise was expensive, but worthwhile.
Inexperience led to some otherwise avoidable disappointments.
RRPM or derivatives thereof are expected to be of aid in planning and decision making at Washington State University.
No single model will meet all of any institution's needs.
No given model will continuously satisfy any given need.
The tools of problem solving must be responsive to the ever changing problems at hand.

Relative to its applicability to other institutions, it is our feeling that RRPM reflects a sound conceptual technique for predicting gross resource requirements and expenditures of an academic institution. It should be recognized, however, that some of the simulation processes used in RRPM may not be particularly appropriate for a given institution. Thus, we suggest that each new user carefully analyze the structure and capabilities of RRPM and where appropriate, make the modifications necessary to reflect its unique institutional characteristics and needs. The model's modular structure assists in this task. Above all, the institution must be willing to expend the effort required to acheive a successful application. RRPM is a valuable and workable tool but not a cure-all.

Washington State University has gained much from being a pilot test institution. We hope that the results of our effort, through the publication of these documents and our participation in the training seminars, will substantially reduce the time and effort required by other institutions to implement a cost simulation model.

Background:

The growing inadequacy of year to year decision making without an adequate amount of long range planning has become increasingly apparent. As a consequence, executives and administrators of institutions of higher education are becoming keenly interested in Management Information Systems (MIS) and other tools necessary to prepare, validate and implement long range planning techniques. In addition to more accurate and timely information, a vehicle for predicting and accessing the immediate and long range effects of particular decisions is required. Modeling, via computerized simulation type models, is proving to effectively meet this need.

Executive administrators of Washington State University have been interested in MIS, and in particular the development of planning models, for a number of years. In the late 1950's, a new budget, accounting, and reporting procedure was adopted which established a common format for reporting and analyzing financial data for all four-year institutions in the State of Washington. In the late 1960's, another inter-institutional co-operative effort developed mathematical models for the preparation of state budget requests for the programs: 1) Instruction and Departmental Research, 2) Libraries, 3) Physical Plant, and 4) Student Services. At the same time, a computer-based space projection model was developed under the direction of the Vice President for University Development. In addition, improved techniques for forecasting instructional needs were developed by the Office of Institutional Studies.

In 1969, the Western Interstate Commission for Higher Education (WICHE) undertook the development of an educationally oriented Resource Requirement Prediction Model (RRPM). Washington State University was selected to participate in the development and subsequent pilot testing of the finished product. Initial interest arose from the perceived likelihood that: 1) RRPM and other WICHE products would be adopted by state and federal agencies and subsequently affect the institution's mode of operation, and 2) an opportunity to mold and expand the existing four submodels into an integrated total university model would arise.

As a member of the RRPM task force, Washington State University personnel played a major role in the development of RRPM and, as a pilot test institution, agreed to undertake the following tasks:

1) Model Implementation - achieve a full set of RRPM outputs completely based upon historic data and current operational standards.

2) Model Validation - adjust or modify the parameters of the implemented model to achieve maximum reality and prediction accuracy.

3) Model Evaluation - secure an evaluation of the usefulness of the model for planning and decision making by major executives.

4) Sensitivity Analysis - develop an analytic approach to sensitivity analysis and demonstrate its practicality relative to RRPM.

The following sections each describe the accomplishments and experiences encountered in performing the above tasks. Emphasis is placed upon brevity and focuses upon information which is believed to be a benefit to potential users of RRPM.

Implementation of RRPM:

Implementation of RRPM, as defined above, consumed approximately one calendar year of time and a total of approximately two man years of effort. This constitutues approximately 70 percent of the total pilot test effort excluding sensitivity analysis activities. Of this time, approximately 45 percent was devoted to data gathering and conversion, 20 percent to data analysis, and 35 percent to parameter and relationship determination.

To implement RRPM, historic data had to be converted from existing to RRPM compatible classifications and formats. This required the aggregation of existing data. Fortunately, data was available in sufficient detail that conversions could be made via crossover tables. Crossover tables were prepared for the following data classifications: 1) program structures, 2) academic departments, and 3) staff and faculty classifications.

Calculation of model relationships, coefficients and paramenters were all based upon actual expenditures as contrasted to budgeted figures. When comparing expenditures with budgeted amounts, it was not unusual to note significant deviations.

Almost all information was available in machine readable form although distributed over a large number of files. FTE calculations were based upon actual man-month expenditures as recorded on the position control file. Supply expenditures were taken from annual financial reports. Faculty requirement coefficients were derived from course enrollment data maintained by the Registrar and from Faculty Activity Analysis records. Enrollment projections were based upon present trends derived from institutional records and supplemented by data derived from the Higher Education Enrollment Projection (HEEP) model. The HEEP model is used statewide and was developed within the governor's office.

The space and facilities portion of RRPM was not tested. Washington State University currently uses a projection technique based upon concepts described in the book entitled University Space Planning. The methodology is substantially different to that employed in RRPM. Since time did not allow a conversion in either direction, the standard relationships and paramenters included in the WICHE test data were used. Members of the Office of Facilities Planning made a number of recommendations, some of which are being implemented in the released version of RRPM. A complete report of their evaluation of RRPM space projection methodology is included in our full pilot study report.

A number of problems were experienced in developing meaningful relationships from historic data. As an example, the Computer Science Department emanated from previously existing areas. The sudden appearance of a significant new department and corresponding reductions in parent departments could not be predicted on the basis of historic data. The future growth or decline of the new and parent departments was similarly impossible to forecast from historic data. Similar problems arose when a functional area identified in the PCS, or the HEGIS discipline divisions, was not identifiable within the existing accounting structure. For instance, Student Financial Aids is carried under the budget for the Dean of Students and not uniquely identifiable. These and numerous other situations had to be resolved on an individual basis.

In particular instances, data items required to implement RRPM appeared to be available in machine readable form but upon investigation, were found to be defined differently, improperly coded, or not updated. As an example, course contact hours were available in machine readable form. However, upon analysis, they were often found to be inaccurate due to inconsistent updating. Current changes in course offerings and teaching methodologies were not always reflected in the data.

Validation:

Validation of RRPM consisted of verifying that the outputs produced by the model correctly reflected the specified relationships and inputs, and that the model adequately predicted current and past resource requirements. This exercise consumed approximatley six calendar months of time and five man months of effort. The resultant model predicted current detailed and agregate costs within an accuracy of $\pm$ 10 percent.

Validation and implementation of the model were joint ventures. As portions of the model were brought to an executable state, the results were analyzed at both the detailed and aggregate level. When unexpected or unusual values are encountered, both the data and relationships were reviewed. Where appropriate, relationships and parameters were corrected or adjusted to more closely reflect reality. For instance, the original teaching faculty projections were in error by as much as 50 percent in specific disciplines. As a consequence, data obtained from Faculty Activity Analysis records were reevaluated. A number of errors were detected relative to jointly taught courses, sabbatical leave, and contributed services. When these corrections were made, the results produced by the RRPM model were well within limits achieved by existing techniques.

Limited data occasionally caused regression relationships to reflect short term trends rather than long range relationships. Detection of these situations and their resolution was a significant part of the model validation process. Upon occasion, what appeared to be an error or unreasonable result was determined to be a current misconception. The purifying of current data and the development of new understandings were all benefits of this phase.

Without proper validation, not only these benefits would have been lost but the resultant model would have been of questionable value.

Executive Evaluation:

This section summarizes statements and opinions of the Executive Vice President of the University, various Vice Presidents, and the Director of Systems and Computing.

Typically, models have not been satisfactory as automatic predictors of the future nor extremely helpful in understanding historical University data. The limited use made of RRPM to date tends to negate the latter finding and has been the prime benefit received.

We have submitted a number of "what if" questions to be answered by RRPM. Although the resulting predictions were not operationally useful, two classes of benefits occurred. First, a better understanding of: 1) the kinds of questions which should be asked, 2) how to ask them, and 3) when RRPM offers a potential advantage over alternative techniques, was achieved. Second, RRPM was found useful in predicting extreme or limiting situations. An example was its use to predict total university cost, first assuming a six percent and then a zero percent inflation factor. The results were enlightening. In general, however, values obtained via RRPM are not sufficiently accurate to provide a sole or even primary basis for making operational decisions.

Experience and tailoring to meet a specific institution's needs can undoubtedly increase the usefulness and reliability of RRPM, particularly as a gross predictor of resource requirements.

Economic and environmental changes, legislative and administrative decisions, and other factors, often a feedback nature, are necessary considerations in any valid long range plan or decision. In its current regression oriented form, these factors are not easily, if at all, characterizable within RRPM. The results of the model therefore, require careful subjective and objective analysis and evaluation prior to use.

Assuming, for the moment, that experience and dedication would produce a valid decision making tool, two problems remain. Data generated from RRPM could be analyzed and interpreted by insufficiently experienced individuals within the institution and lead to improper internal decisions. Secondly, outputs may be analyzed by individuals external to the institution (another institution, council of education, or legislative body) and again due to inexperience, arrive at incorrect conclusions. This will be particularly true if data from several institutions are used for comparative purposes. The tailoring and finesse required to make individual models operational at each institution seriously complicates the use of multi-institutional data in aggregate planning and analysis.

Returning to more concrete factors, it should be noted that a 10 year simulatio of Washington State University required 10 minutes of Central Processor time and cost $428 on our IBM 360 Model 67 system. Furthermore, 250 bytes of core storage was required. Frequent running of the model, which would be necessary to make it an effective decision making aid, is prohibitively expensive.

Institutions with lesser systems (less core and direct access capacity) would have to incur substantially increased run times, possibly one-half to two hours per run. Frequent use would severely impact other computer operations unless sufficient excess capacity existed. Institutions with very small systems may not be able to run RRPM at all.

From a positive standpoint, RRPM was brought to an operational status at each pilot test institution without undue difficulty. A wide range of computers as well as a remote terminal and off site batch application was represented.

In summary the opportunity to pilot test RRPM at Washington State University has been a worthwhile and informative, but expensive experience. Development of university models will be continued and encouraged. Although demonstrated to be an indirect management aid, and showing promise as a future decision making tool; RRPM currently does not fulfill the latter need. It is even more uncertain that RRPM or any other non-interactive (man machine) system will ever produce data which is truely interinstitutionally comparable. At best, RRPM can remove some of the technical inconsistencies currently encountered.

Sensitivity Analysis:

A separate but also significant task undertaken as part of the pilot test study was the development of an analytic sensitivity analysis technique. The object of a sensitivity analysis is to identify variables and relationships to which a model or system is sensitive, i.e., factors for which a nominal change induces a significant change in system cost or behavior. Investigation is usually focused upon controllable variables and relationships, in that they constitute factors which can be willfully changed to achieve desired results. Relationships to which a model is sensitive and about which there is substantial uncertainty are also significant.

Typically, sensitivity analyses are performed by varying the value of one or more variables and noting the resultant changes in output. This requires a large number of iterations and is costly and time-consuming; particularly when the model is large, complex, or only partially understood. The purpose of this effort was to develop an analytical approach to sensitivity analysis which would be more direct, less costly, and less limited.

The approach taken was to write a FORMAC program which allows the user to request any relationship implied by a given model to be displayed in explicit form. A sample request would be to display the sum of instructional and research costs (dependent variable) as a function of average class size and faculty rank (in dependent variables). Via multiple substitution and other algebraic routines, the program produces the required relationship in algebraic simplified form. All constants and variables which are not a function of class size or faculty rank are assimilated into the equation at their current value. The resultant coefficients measure the sensitivity of the dependent variable to each of the specified independent variables. Derivatives of the derived equations may also be requested to be displayed in a like manner.

The application of these techniques provided a relatively simple and cost effective method for obtaining a comprehensive and quantitative understanding of the RRPM model developed at Washington State University. Results were also beneficial in validating initial model results. Individual answers ranged in validating initial model results. Individual answers ranged in cost from $.50 to $2.00 depending on the complexity of the resulting relationship.

Whether or not the task would be equally simple for a more complex or heterogeneous model structure, or if attempted by a less mathematically inclined individual is questionable. The fact, however, stands that an analytical approach offering major advantages over a numeric approach was successfully developed and implemented.

The program developed is relatively specific to the Washington State University model and has only moderate transferability. Program and work space requirements are such that inclusion of the total RRPM model as a single entity is impracticable. The model implemented spanned the range from total cost to the lowest level at which costs appeared. Nevertheless, it is believed that the development of this technique represents a significant step forward in the area of sensitivity analysis. Pursued on a production basis as constrasted to the feasibility approach taken, many of the constraints currently present could be removed.

Advisory Structure for the NATIONAL CENTER FOR HIGHER EDUCATION MANAGEMENT SYSTEMS at WICHE

EXECUTIVE COMMITTEE

Dr. Frank C. Abbott
Executive Director
Colorado Commission on Higher Education
(July 1, 1973)

Rutherford H. Adkins
Vice-President
Fisk University
(July 1, 1973)

Dr. Thomas F. Bates
Vice-President for Planning
The Pennsylvania State University
(July 1, 1973)

Donald H. Clark
Chairman of the Higher Education Advisory Committee to the Midwest Council of State Governments
(July 1, 1973)

Dr. Joseph P. Cosand
President
The Junior College District of St. Louis
(July 1, 1973)

Kenneth Creighton
Deputy Vice-President for Finance
Stanford University
(July 1, 1973)

Paul V. Cusick
Vice-President for Business and Fiscal Relations
Massach'isetts Institute of Technology
(July 1, 1972)

l Davis
inancial Vice-President
University of Utah
(July 1, 1973)

Dr. Alan Ferguson
Executive Director
New England Board of Higher Education
(July 1, 1973)

Loren Furtado
Assistant Vice-President
University of California
(July 1, 1972)

Richard Gibb
Commissioner of Higher Education
South Dakota State Board of Regents
(July 1, 1973)

Robert L. Harris
Vice-Chancellor
California Community Colleges
(July 1, 1972)

Dr. Bert Y. Kersh
Dean of Faculty
Oregon College of Education
(July 1, 1972)

Samuel Lawrence
Vice-President for Administration
Cornell University
(July 1, 1972)

Dr. Roy Lieuallen
Chancellor
Oregon State System of Higher Education
(July 1, 1972)

Douglas MacLean
Vice-President for Staff Services
University of Houston
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Assistant Commissioner for Higher Education Planning
The University of the State of New York
(July 1, 1973)

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State University System of Florida
(July 1, 1972)

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Chancellor
The Minnesota State College System
(July 1, 1973)

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Assistant Vice-Chancellor for Management
State University of New York
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Vice-President for Planning and Budgeting
University of Washington
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Associate Director for Research
Southern Regional Education Board
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